Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

EDITORS

JAMES D. AND EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS JOSIAH P. COOKE, GEORGE L. GOODALE AND JOHN TROWBRIDGE, OF CAMBRIDGE.

PROFESSORS H. A. NEWTON AND A. E. VERRILL, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA.

THIRD SERIES.

VOL. XLIV.—[WHOLE NUMBER, CXLIV.]

No. 262.—OCTOBER, 1892.

WITH PLATES VI–VIII.

NEW HAVEN, CONN.: J. D. & E. S. DANA.

1892.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 371 STATE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

RARE DIAMOND CRYSTALS.

A fine importation, including many twins and other rare forms just received, $2.00 to $20.00.

AUSTRALIAN OPALS.

With the exception of our magnificent $500.00 specimen (sold a year ago) the specimens we now have are the finest ever in our store. $2.50 to $35.00.

PHENACITES FROM NEW HAMPSHIRE.

Choice loose crystals, $1.00 to $2.00 each.

TWIN PHENACITES FROM MT. ANTERO.

A very few of these excessively rare crystals have been secured by our Colorado collector. $2.00 to $10.00. Also a splendid lot of loose crystals of the ordinary forms both from Mt. Antero and Florissant, 10c. to $10.00.

GEM OLIGOCLASE FROM NORTH CAROLINA

This very interesting, colorless and transparent variety is now in stock in excellent specimens, 25c. to $1.50.

GREEN TOURMALINE CRYSTALS.

Choice, terminated, gem crystals from Maine, 50c. to $2.00.

FROM NORTHERN NEW YORK: Peristerites, Green Fluors, Black and Brown Tourmalines, Hexagonite, etc.
FROM CANADA: Wernerites, Pyroxenes, Singly and Doubly Terminated Apatites, Single and Twin Titanites, Zircons, etc.
FROM NEW MEXICO: Superb Yellow Wulfenites, Turquois, Precious Garnets.
FROM CALIFORNIA: Beautiful, radiated Rubellite in white Lepidolite.
FRON ARKANSAS: Huge Vesuvianite Crystrals, Strong Lodestone, Rutile Rosettes, Brilliant Brookites, Pink Eudialytes, Rare Monticellite Crystals.
From all parts of the world shipments constantly arriving.
Penfieldite (new), Fiedlerite, Phosgenite, Laurionite, etc., from Greece.

CROCIDOLITE. Finest lot ever seen just secured, including richest blue and yellow mottled specimens, extra large, $1.00 to $5.00.
AGATES. Remarkably choice lot large polished pieces; perfect "bull's eyes" and "fortifications" in black and red, $1.00 to $7.50.
LABRADORITE, polished, rare colors, 25c. to $1.50.
MALACHITE, polished, good, Arizona and Russia, 10c. to $1.00.

. Dana's New "System of Mineralogy," only $10.00.

---

100 pp. Illustrated Catalogue, 15c.; cloth bound, 25c.; Supplement, 2c.; Circulars free.

GEO. L. ENGLISH & CO., Mineralogists,

733 & 735 BROADWAY, NEW YORK CITY.

THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XXXIV.—*On a Color System;* by O. N. ROOD, Professor of Physics in Columbia College.

[Read before the National Academy of Sciences, Nov. 12th, 1891.]

IT is possible to combine by rotation a circular disc of cardboard painted with vermilion, with a similar disc covered with a bluish-green pigment exactly complementary to the red, and to ascertain whether by mixture a gray is produced when the two colored areas are equal. If such should be the case, in a certain sense we could say that these two colors were equal, in spite of differences of luminosity or amounts of white light mingled with them. If it were found that to make the mixture neutral, more or less red were required, we could assign to the vermilion disc a coefficient of 1, and to the blue-green disc its proper coefficient whatever that might be. Supposing for the sake of simplicity that the coefficient of the blue-green disc was also equal to unity, we then could mark the positions of the two colors at the extremities of a straight line and at its middle point locate white (gray), and we would then have a line containing, so to speak, all possible mixtures of these two colors, and by simple processes could indicate on it the positions, and consequently coefficients, of any red or blue-green surfaces having hues of the same character; for example, a red surface reflecting half the amount of red light of our standard disc, would be located half way between the positions of the standard red and of white, while another red disc might even find its position on the same line outside of our standard. In all these cases the vermilion disc would be the material stan-

dard to which a great number of reds and blue-greens, more or less pale or intense, could be quantitatively referred. But it might be possible to go farther, and to be able to say that our standard vermilion disc reflected the same amount of red light that is furnished by white card-board under the same illumination, or that at all events it reflected a known fractional part of it. All the colors just spoken of would then be virtually referred to white card-board, or to some other white reflecting surface as might be determined on, and the standard red disc could at will be reproduced at any time or in any part of the world. To the reproduction of standard red discs I have not devoted much time. as before they can be made valuable a much more difficult problem must be solved.

For if we undertake to go farther than the proceeding just indicated, and build up a whole system of colors we are immediately confronted by the fact that we are quite unable to leave our line; or for example, to express the amount of orange colored light or of green light reflected by other discs in the same terms, or to bring them all into one system. As Helmholtz has remarked,* masses of colored light which when mixed with their complements furnish in pairs the same white, may be said to belong to the same system and may be located at equal distances from the same center. A set of ideal discs which when combined pair-wise all furnished the same white, would in this system find their positions on the circumference of a circle with white at the center. But it is not practicable to experiment directly in this way, as it is nearly impossible to measure directly the amounts of white light mingled with the colored in the case of painted surfaces.

I have employed a different proceeding and built up with it a reproducible system, which, as far as I can ascertain, is the one above indicated. Let us suppose that the positions of our standard red and its complement have been laid down at the extremities of a line with white at its center: we then combine with the red disc a green which is a little too blue to be strictly complementary, and obtain the best neutralization, the gray furnished having the least perceptible color, and we will suppose that this takes place when the areas of the two colored surfaces on the composite disc are equal; we shall then know that the new color also belongs on the circle not far from the complement of vermilion. One step has thus been taken, we have been able to leave our first line of mixtures. We can then with ease and certainty locate the complement of this new hue, which will be a little more orange than the vermilion; or better still, we may combine the new color with one that is

* Handbuch der Physiologischen Optik, p. 287.

still more refrangible than its true complement, and locate a disc which is still more orange, advancing thus more rapidly in the work. In the same way this orange-red disc will enable us to add a still bluer green, until in this way all the colors of the chromatic circle have been provided for and all our colored discs have *received coefficents*, for of course it will rarely happen that the actual positions of the colored discs fall on the circle, mostly they will be well inside of it. The first part of the work then consists in assigning coefficients to a series of painted discs which are arranged so as to have only small progressive differences of color.

Mode of experimenting.—To compare together colors which are not strictly complementary a number of precautions must be taken. In the first place, the pairs of discs employed should always have as nearly as practicable about the same coefficients; consequently the selection of the colored papers offers very considerable difficulty, and in the majority of cases it has been necessary for me to prepare the paper specially for each case as it arose. Of course it is desirable to use papers with as high coefficients as possible, but cases occur where one is compelled to use lower coefficients (blues and cyan blues) and in these it is always necessary, so to speak, to take a fresh start, and to descend to the lower coefficient by a line passing through the center of the circle and not outside of it, that is by reaching the other side of the circle by the aid of a *complementary* disc with a lower coefficient.

It is absolutely necessary that the eyes should be thoroughly rested after each individual observation, and they should be protected from side lights by a hood. Only the central portion of the retina should be used; that is, the colors should be observed through a small aperture in blackened card-board held at arms length. It is an advantage and a saving of time, to protect the eyes with quite dark neutral spectacles while engaged in the manipulations not involving observation of the colors.

As a source of illumination, sunlight falling on a stretched sheet of bleached cotton cloth was employed, and only the hours near noon were utilized. The frame with the white cloth was outside of the window, inclined at a suitable angle, and consequently was behind the observer as well as placed symmetrically to the colored discs. Extraneous light from buildings and blue sky was screened off and the room suitably darkened. If light from a uniformly overcast sky is employed a different set of coefficients will be obtained, and there is reason to believe that they vary somewhat with the nature of the sky on such days.

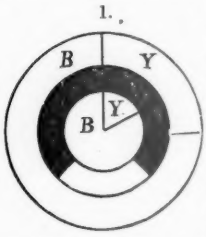
In some observations it was found advisable, for the sake of using high coefficients, to employ paper which was slightly fugitive, but by properly arranging the process the evil effects of this were obviated.

The coefficients of two strictly complementary discs are as their distances from the center or from white, and this distance is of course measured along the two radii that make up the diameter, but in the method used by me for colors not strictly complementary, the cosine of a small angle is necessarily employed and treated as if it were a radius. The angles used however were quite small, from 1°·5 to 3°, and consequently the error in any individual case was insignificant, but it is cumulative and finally becomes comparable with those of observation. After the uncorrected results have been plotted in a Newton's diagram, the angular distances of the colors will be known, very nearly, and the small errors from this geometrical source can be corrected and a fresh diagram constructed.

As above stated, it was not found advisable to employ angles larger than about 3°, since with larger angles the results were more uncertain, while with the angle above indicated the manipulation was hardly more difficult than in the case of truly complementary discs.

Mode of ascertaining the most neutral mixture.

Let us suppose that we wish to obtain the most neutral mixture that can be furnished by yellow and blue discs that are not complementary; the best method of procedure according to my experience is the following: a pair of large blue and yellow discs are combined as shown in figure 1, and on the same axis comes a black and white disc destined to furnish the comparison grays, and again on this, smaller yellow and blue discs cut from the same papers. Of course these three compound discs can be varied independently of each other. We start now with an amount of yellow on the larger disc which is far too small for approximate neutralization, and on the smaller disc with still much less yellow, and call the difference between the sectors the interval. This interval in any given case is always to be kept roughly constant, and the more nearly complementary the discs are, the smaller it may be made. There is however no gain whatever in trying unduly to diminish it, and such attempts tend only to defeat their object, it being far better and safer to have the interval too large than too small. The arrangement in figure 1 indicates



1.

about the first position for discs that have nearly the same coefficient, but are quite removed from being complementary. As soon as the compound disc is set in rotation it will be noticed that the mixture-tint furnished by the larger disc is the least colored of the two, and the amount of yellow in it is to be increased, the smaller disc following with the same interval, and this proceeding is to be pushed forward till the observer is unable to decide whether the larger or the smaller disc is the paler, the least colored. Both will differ sensibly from the pure gray mixture, and the two pale mixtures will differ from each other in hue, still after some practice the observer will learn to decide with promptitude that they differ about equally from gray. This is a much more certain and easy process when in general only a little color is present, than when the hues presented are at all decided, and this is the reason that in building up the system the advances were made by small steps. The first half of an observation being now made and the mean noted, the yellow element is made from the start to preponderate considerably, the interval is preserved, and with a reversed approach the best neutrality obtained. The two readings constitute one complete observation, and if the maximum reliability is demanded, not more than five complete observations in any one case should be made on the same day, it being more profitable to devote the remaining time to other determinations.

As an example of the results to be attained I give three sets of determinations for five discs with rather low coefficients, each number being the mean of only three complete observations made on the same day:

CB9*a*	·585	·575	·585
Y6⅓	·506	·480	·486
CB8	·466	·442	·452
Y6½	·432	·421	·428
B28	·394	·384	·398

When it is remembered that in photometric observations involving light of the same color the error in any one observation may easily be two per cent and more it will be seen that these results are satisfactory so far as uniformity goes.

By the methods above indicated I obtained the coefficients of a series of slightly differing discs ranging in color from orange-yellow through red into purple, and on the other hand from a somewhat yellowish green through cyan-blue to blue. Then, instead of extending the process all around the circle, a Newton's diagram was constructed using the standard vermilion disc, the extreme green attained and the blue. The

angular positions of these colors were not arbitrarily assumed, but determined from the mixture equation and the ascertained coefficients. With the aid of this triangle and color equations experimentally obtained, I plotted in the usual way the positions of five of the discs used in the building up process, and calculated their coefficients with the following result:

	Direct coef.	Calculated.
G1	1·119	1·109
O1	1·221	1·231
P12	1·229	1·257
G18	·867	·892
P1	·571	·566
GY5	·806	·795

GY5, a greenish yellow, was quite beyond the limits of the triangle.

This agreement shows that the zig-zag process employed by me is homogeneous with that ordinarily used in Newton's diagram, and from this it follows that it is not necessary to determine by my method coefficients for a greater number of discs than will furnish a properly shaped triangle, and that the remainder of the work can be done by the older method. It may here be remarked that in obtaining the fundamental equation for the construction of the diagram and those for locating the colors, it is necessary to exercise far more suspicious care than is the case in the direct determinations of the coefficients. Although a pure gray is always attainable, theoretically, yet it seldom is obtained quite to the satisfaction of the observer; the best way is to employ on the same axis duplicate sets of discs separated by the comparison gray, to vary the manipulation and multiply the observations. The work having progressed thus far it becomes possible to ascertain the coefficient of any colored surface and to assign it a position in the diagram.

It may be remarked that the angular positions assigned to colors by the method just described agree in their main features with those given by me in a diagram on page 250 of "Modern Chromatics," which is founded on contrast observations, the main differences being in the angular positions assigned in the diagram to violet and blue-violet; these would have to be moved about 15° to the right, i. e., nearer to the other blues to make them coincide with positions furnished by this system.

I give here some of the coefficients obtained: the vermilion with a coefficient of 1 had only a moderate brilliancy, being made of English vermilion applied to card-board as a paste: since then I have found in the shops a red, supposed to be vermilion, with a coefficient as high as 1·174.

Chrome yellow (paste)	·846
" "	·933
"Pale" " "	·991
Emerald green "	1·119
Prussian blue (wash)	·354
" " "	·392
Cobalt blue (paste)	·562
Artificial Ult. blue (paste)	·506
Crimson lake (wash)	1·23

The system which is here proposed can be built up by experimenters and ought to be practically identical in all cases if made by normal eyes, provided the same standard vermilion is used, or the coefficient of it is known, or in general if the starting point is made from any disc of bright color the coefficient of which is known. As before stated it may be possible hereafter to refer the coefficient of the vermilion disc to white card-board, which indeed has been done in the case of my own disc with some approximation to correctness. The system may then be considered a fairly reproducible one, but the question still remains as to its nature. The thought that in it we have one where complementary colors having a determined coefficient of unity furnish the same gray, naturally suggests itself and is rendered probable by the following considerations. The standard red and its true complement when mixed furnish a certain gray, and it is evident that other pairs situated at small angular distances from them, such as 10° on either side, will sensibly do the same. This furnishes two sectors of 20° on either side of white; but the coefficients of the colors situated within them are reproducible with the aid of the triangle, which would hardly be the case unless the colors situated at its angles obeyed the same law, viz: furnished the same white when mixed with their true complements; this again applies to the reversed triangle and the two provide for about two opposite quadrants of the circle, and what holds good of these ought, it would appear, to apply to the remaining quadrants.

The question whether in this system, all the colors located on the circumference furnish by mixture the same white when treated in pairs, is quite difficult to answer by actual experiment, as in the case of most of the discs it is very hard to ascertain the relative amounts of colored and white light reflected, owing to the well known fact that in most cases portions of the colored light mix, and produce what amounts to an indeterminate amount of white light. Some attempts, with the aid of the spectroscope, of colored glasses and of gray discs were made to measure the actual amount of standard

white (gray) furnished by the mixture of the *pure* fundamental red and its pure complement; a number was obtained expressed in terms of the luminosity of white card-board, and the same operation was performed for complementary yellow-green and purple as well as for yellow and blue discs. Without laying much stress on the results obtained, it can at least be said that they did not render improbable the idea that these pairs all furnished equal grays when united. To settle this problem experimentally would of course require a considerable amount of elaborate work, if indeed it is at present capable of such solution.

I shall be glad to furnish without cost samples of colored paper with coefficients to those who are particularly interested in these matters.

ART. XXXV.—*An Ottrelite-bearing Phase of a Metamorphic Conglomerate in the Green Mountains;* by CHARLES LIVY WHITTLE.

[Published with permission of G. K. Gilbert, Chief Geologist, U. S. Geological Survey.]

THE geological position of the limestone and quartzite of the Rutland valley has lately been definitely determined, the limestone paleontologically and the quartzite stratigraphically.* Occurring next below the limestone the quartzite is the northern continuation of the Clarksburg-mountain quartzite in Massachusetts in which Walcott has found the Olenellus fauna characteristic of the Lower-Cambrian horizon. About one mile north of Rutland village, in Vermont, Dr. Wolff and Dr. Foerste were fortunate enough to find Lower-Cambrian fossils in a siliceous limestone that lies superjacent to the quartzite. Northeast of Rutland the quartzite is found associated with a sandy, phyllitic schist that belongs to a series of metamorphosed clastics having a vitreous quartzite or conglomerate at its base. This whole series, barring the Lower Cambrian quartzite and limestone, has been subjected to the most intense dynamic action. The sequence of the different members of the series is in many regions hopelessly obliterated and confused by the mountain-building forces that have produced new structural planes and a new mineral composition; and have additionally complicated the geological order of succession by sharp folding, as a rule too much

*On the Lower Cambrian Age of the Stockbridge Limestone. Bulletin Geol. Society of America, vol. ii, pp. 331–338.

involved for decipherment. These phenomena are particularly true of the conglomerate horizon and its many phases, and it is in this rock that I wish to describe some of the evidences and effects of metamorphism shown by the destruction of old clastic minerals and in the production of new ones.

Occurrence of ottrelite schist.—One of the most conspicuous phases of the conglomerate is due to the development of ottrelite in great abundance so that it is not uncommon to find fully twenty-five per cent of the rock made up of this mineral. The ottrelite is commonly most abundantly developed where the rock has now a well-marked schistose character that is due either to an original fine-grained deposit, or is a result of the shearing and crushing action of dynamic forces. It is often found, however, occurring in the groundmass of the coarsest conglomerate or along planes of shearing in a blue, hyaline quartzite. Still another phase is more nearly massive, fully forty per cent being ottrelite, the rock at first sight simulating in appearance some porphyritic hornblende dike. The rock is a very variable one, but, considered as a whole it forms one of the most important stratigraphical horizons found in the more crystalline areas of the Green Mountains. In lateral extension it has been traced with unimportant breaks all the way across the Green-mountain anticlinal axis, as mapped by Hitchcock,* from Mendon, Vt., to North Sherburne, Vt. In vertical extension it has considerable thickness although accurate determination is very difficult owing to the obliteration of planes of bedding in many instances and the complexity of the flexures; but it seems safe to assume a thickness of several hundred feet, at least in several localities that have been most carefully studied, viz: a spur extending south from Mount Carmel, in the town of Chittenden, and the east and west crest forming the southern portion of the mountain, somewhat inappropriately named "Old Aunt Sal," in the town of Mendon. The phases studied thus far in the laboratory are from this latter locality and from the western part of the "Rabbit Ledge" just south of Mendon "City."

Physical and microscopical characters.—In the hand specimen the ottrelite of the most massive occurrence of the ottrelite-bearing rock appears either as isolated areas generally with rudely circular outlines, or groups of these in a background of fine-grained, pinkish-brown to dark purple quartz, in places constituting nearly pure ottrelite. These areas possess an approximate common diameter of about three-sixteenths of an inch. In structure they are made up of tabular areas of radiating imbricated plates generally arranged in essentially one plane for any single area; but the positions of the

* See fig. 4, Section VI, Hitchcock's "Green Mountain gneiss," Geol. of Vt., vol. ii, 1861.

different areas seem in the main to be accidental, although locally they may be arranged parallel, as shown by a tendency in the rocks to cleave into rude slabs,—a tendency augmented by thin folia of sericite. A well-marked spherocrystalline habit characterizes all the ottrelite areas; in some this radiated growth seems to be perfect.

Microscopically the radiated structure is much more evident; composite and fan-shaped areas, penetrating one another irregularly coexist with isolated prisms and beautiful spherocrystalline aggregates yielding imperfect crosses in polarized light. Only sections cut parallel to the bundles of plates (basal sections) show well the radiated structure; all other sections show this character less and less, dependant upon the plane of the section until it is transverse when the mineral appears prismatic. The areas of the spherocrystals are not infrequently bounded by overlapping six-sided plates of which three are usually free; the others are intergrown and confounded in the central portion of the aggregate.

The extreme mobility of the ottrelite-bearing solution is indicated by the manner the ottrelite needles have insinuated themselves into included feldspar grains along no visible lines of fissuring.

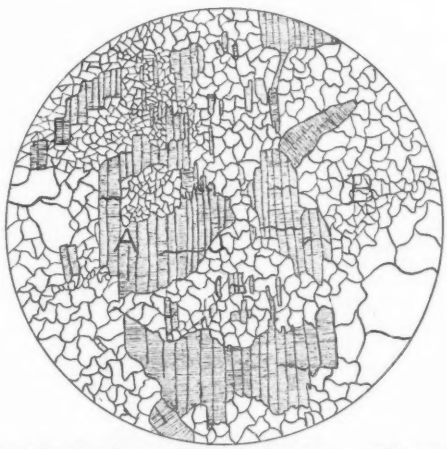
As in all described occurrences of this mineral an abundance of inclusions exists. It is noticeable that while quartz and occasionally feldspar are included, sericite, which is the principal micaceous constituent of the rock, is seldom enclosed by the growing ottrelite, but may be wholly or in part the nucleus about which an aggregate formed. Such nuclei seem to have governed the growth of the ottrelite. There is a tendency as the mineral formed for the plates to orient themselves parallel to the sericite nucleus so that when such a nucleus is surrounded by basal ottrelite it is apt to be basal also. By far the most abundant interpositions are a multitude of extremely minute black to brown dots and aggregates. These with a No. 7 objective are resolved, in the main into rutile occurring in knee-shaped and heart-shaped twins but generally in rounded forms in which twinning is not distinguishable. In other cases the highest objectives are incapable of individualizing the grains as is mentioned by Rénard in his "Researches Sur la Composition et La Structure Des Phyllades Ardennes."* In some crystals the rutile is grouped in reticulated lines conforming rather rudely to the planes of the two principal cleavages; but, as a rule grouped along irregular lines that traverse the ottrelite and the groundmass alike, and was arranged originally in structural lines, possibly depositional

*Phyllade Ottrélitifère de Monthermée: Bulletin De Musée D'Hist. Nat. D Belgique, 3, 1884, '85, p. 252.

that afterwards were built into the ottrelite with total disregard to any observed relationship, in the same manner that quartz and feldspar droplets were built into albites in another phase of this rock. Other inclusions are graphite (determined by deflagration) and little coffee-brown ilmenite plates (titaneisenglimmer). A powerful current from an electromagnet applied to the rock powdered and run through a 120-mesh sieve failed to attract but little, so that magnetite and probably ferrous oxide are absent. The usual test for titanium gave a positive reaction.

As in biotite and chlorite, pleochroic zones about crystals of zircon are very common in the ottrelite and the characteristic dependence of maximum pleochroism upon maximum pleochroism of enclosing mineral is observable. While zircon usually occupies the centers of these zones, others occur, having no perceptible associated inclusion, but are circular areas of a brownish color, not resolvable with the highest power, that are probably rutile grains.

1.



Ottrelite schist showing formation of ottrelite at many different points. Each small area is oriented with all the others, forming a large area having a general prismatic outline. The prism (A) has been developed transverse to the schistosity of the rock. The background (B) is largely gneissic quartz with some secondary feldspar. × 25.

Although twinning with composition face parallel to O is not uncommon in the ottrelite a large part of what seems to be twinning is seen to be due to overlapping plates. As the stage is revolved the wavy extinction caused by this may be observed, — the usual spherulitic structure. Examples of crystal growth set up in several places at the same time occur

in the rock, where each part is controlled by every other, resulting in an irregularly-outlined prism composed of many individuals. These parts are separated by areas of the groundmass and yet are all oriented together (see fig. 1). This phenomenon is unlike that of andalusite, which occurs so frequently grown into large individuals enwrapping all other minerals of the background; but is another example of independent parallel growth analogous to that of quartz in pegmatite. Such growths are commonly developed nearly at right angles to the layers of quartz and feldspar that make up the schistosity, and are usually freer from inclusions than the bundles. They occur between the main areas of ottrelite and may represent a second generation; they were necessarily formed after the groundmass was converted to a mosaic by granulation.

The same phenomenon is noticed in the rutile. Little yellowish-brown grains of this mineral developed in the interspaces of the minerals composing the background tend, although made up of separate and sometimes isolated grains, to orient themselves parallel to one another, forming groups having prismatic outlines. These groups are only sparingly developed, but when observed they are generally parallel to one another and to the schistosity of the rock and are restricted in their occurrence, like the ottrelite individuals just described, to the most quartzose parts of the rock which they enclose in the same manner as the ottrelite.

An interlamination of chlorite and ottrelite at first glance was mistaken for either the contemporaneous formation of these minerals or an infiltration of chlorite parallel to the basal cleavage of the ottrelite. Further investigation, however, showed that the chlorite as often traversed the ottrelite irregularly in bifurcating veins and enclosed parts of it (see fig. 2). A study of the nature of these veins convinced me that the chlorite is an alteration product of the ottrelite. The edges of the veins where they traverse the ottrelite transverse to the basal cleavage are jagged, the saw-like teeth projecting along the composition faces or basal cleavage. The chlorite in such cases is distinctly made up of little fibers which have arranged themselves parallel to one another and to one set of twinning lamellæ. Lines of inclusions once continuous in the ottrelite now stop short against interlaminated areas of chlorite showing the evident secondary nature of the latter mineral.

In other places the chlorite is developed along the basal cleavage, leaves this and follows one of the prismatic cleavages and then again follows the basal, making one continuous line, producing steps in much the same manner that garnet does when it undergoes this alteration. Cores of unaltered ottrelite remain in the chlorite and the pleochroic zones once in the parent are

seen again in the secondary mineral, while the relationship of maximum pleochroism of these zones to the greatest pleochroism of the chlorite is handed down as well. This metasomatic phenomenon has not been observed in other phases of the ottrelite-bearing conglomerate thus far studied by me.

2.

Alteration of ottrelite to chlorite. A, overlapping plates of ottrelite. B, bifurcating vein of chlorite allomorphosed after ottrelite and including cores of unaltered mineral. C, quartz and feldspar mosaic.

The background of the rock is composed about equally of quartz and feldspar as principal constituents. The feldspar is fresh and glassy, untwinned and is probably albite; but it is hardly abundant enough in the ottrelite-bearing phases to make the rock a gneiss even in mineralogical composition; and, structurally, a gneissic habit has been nowhere observed where ottrelite exists to any extent. Sericite is also abundant and occurs in minute prisms between the interlocking quartz grains and enclosed by the albite generally, and rarely by the ottrelite. It also encloses lines of rutile dots arranged parallel to its cleavage planes, and, next to the ottrelite it is the last-formed mineral.

Associated with rutile in the groundmass are groups of stout and slender prisms and plates having a very high single and double refraction and a variable color from brownish-yellow to blue even in the same individual. These I identified as anatase and for verification I studied Diller's sections described in his contribution on "Anatas als Umwandlungsprodukt von Titanit im Biotitamphibolgranit der Troas."* Unlike the anatase

*N. J. B., 1, 1883, pp. 187–193.

there described its occurrence in narrow prisms in this rock together with its multitude of rutile inclusions seem exceptional. The stouter prisms have terminal faces of an octahedron and range in size from $\frac{3}{5}\frac{1}{0}$ to $\frac{1}{2}\frac{1}{0}\frac{1}{0}$ of a millimeter in length. As the stage is revolved the pleochroism seems only the intensification of the inherent color of the mineral: browns become browner and blues, bluer. The presence of rutile inclusions shows the anatase to have formed after that mineral and suggests the probability of its being a paramorphic product of the rutile inclusions.

Rutile dots and prisms exist in multitudes enclosed by all other minerals of a secondary nature. They are so extremely minute that even in a very thin section they focus in six or more different planes.

All traces of original clastic material in the rock have disappeared: feldspar detritus, if it once occurred, has been converted into a mosaic of quartz, sericite, biotite and probably albite, and the detrital quartz has been granulated. The existing feldspar is the characteristic untwinned glassy variety carrying quartz and sericite inclusions so common throughout this horizon, and was formed after the granulation of the rock, since granulation could not have taken place without straining or crushing it. Nearly all the quartz is sprinkled with rutile inclusions, but it is noticed the larger areas have less of them and may be cores that have escaped granulation. Their presence, however, in such abundance militates against the probability of any of the quartz being allothegenic and indicates, rather, its secondary nature. In the same way quartz may enclose plates of micaceous ilmenite but does not enclose sericite. There is evidence of two periods of dynamic action indicated by a faint wavy extinction in the feldspar, in some instances and by the bending and breaking of ottrelite prisms.

We have then in this rock three titanium-bearing minerals (ilmenite, rutile and anatase) ottrelite, chlorite, feldspar and quartz. What is their genetic order of development? This is a difficult question to answer without more data and is particularly difficult in the cases of the ottrelite and rutile. The relative position of the former mineral can be determined easily, but the source of the solution introducing it is not easily discovered. Ottrelite was formed after the rock had undergone metasomatic and dynamic changes that converted its clastic feldspar to its resulting minerals, after its detrital quartz was sugared and the rock had become a stable aggregation of minerals under the conditions of environment then existing. This environment changing, owing to one or more of the many factors affecting the character of a rock mass, ottrelite was introduced probably and seemingly necessarily from some ex-

traneous source. The environment of the rock underwent a third change and this was probably an elevation which strained the albites, fissured the ottrelite and subjected the rock to normal surface weathering, during which the conversion of ottrelite to chlorite, was initiated. Prior to the granulation of the clastic constituents the titanium in some combination must have existed in the rock, but the mineralogical nature of this combination is obscure. The most likely source of rutile is from some titanium-bearing iron oxide the presence of which has not been made out definitely except in the case of micaceous ilmenite, itself manifestly of a secondary nature, occurring as it does in a clastic rock, and which yields no evidence of alteration. Ordinary granular ilmenite, such as occurs so abundantly in phyllites, which is prone to decomposition, was most likely the common source for all three minerals carrying titanium, the rutile being an intermediate stage in the formation of anatase. The micaceous ilmenite was developed before the formation of the gneissic quartz, since the latter encloses it; the anatase probably forming after the quartz, as it occurs in the interstices between the quartz grains.

If this be a correct interpretation, the order of crystallization of the existing minerals is essentially as follows: first, rutile and micaceous ilmenite followed by the formation of gneissic quartz enclosing them and coincidently the growth of sericite-enclosing rutile. The glassy feldspars were then formed enclosing all the previously formed minerals, and the anatase may have resulted as an alteration product of the rutile at about this stage in the rock's history. Then the ottrelite began its growth, including all the other minerals in the rock and finally the initial alteration of this mineral to chlorite closes its history up to the present time.

Cambridge, Mass., March, 1892.

Art. XXXVI.—*The Age-coating in Incandescent Lamps;* by Edward L. Nichols.

[Experimental work by Messrs. B. E. Moore and C. J. Ling.]

[Contributions from the Physical Laboratory of Cornell University, No. 11.]

When an incandescent lamp is maintained at constant voltage, it invariably falls off in candle-power. The diminution in brightness is attended by an increase in the amount of energy consumed per candle-power of light; this change being specially marked in the earlier portion of the life of the lamp.

This phenomenon, which seems to take place in all incandescent lamps of the present day, was first studied exhaustively by Mr. W. H. Pierce, who read a paper entitled "The Relation between the Initial and Average Efficiency of Incandescent Electric Lamps," before the American Institute of Electrical Engineers, in 1889.* Mr. Pierce made a careful study of ninety-four lamps, including nearly all the types of glow-lamp then in use. He found no exception to the rule of progressive degeneration.†

These changes may be ascribed to at least three causes: loss of vacuum, increase of resistance, due to the disintegration of the filament, and finally, the deposition of the disintegrated carbon upon the inner surface of the lamp-bulb. It was the object of the experiments to be described in this paper, to make a study of this coating. We endeavored (1) to determine its character; that is to say, whether it is colorless, or is selective in the particular rays it absorbs; (2) to learn something about the rate and distribution of deposit; and (3) to determine how far the absorption of light by the coating is accountable for the diminution in the brilliancy of the lamp.

For the determinations under the first head, we made use of a form of polarizing spectro-photometer which has been more than once described in the pages of this Journal.‡ The standards of light were incandescent lamps. These were maintained at a candle-power considerably below the normal, that the changes taking place in them might be slow. Frequent comparisons of their spectra showed that the relative changes of brightness and quality of light were inappreciable.

The first step in our investigation consisted in the measurement of the absorption spectra of the bulbs of certain unused lamps, which had been selected for study. These lamps were then brought to degrees of incandescence, previously agreed upon, and were maintained in that condition by means of the current from a storage battery carefully kept constant, until they showed coatings of sufficient density to admit of ready measurement. They were then taken out of circuit and the absorption spectra of the blackened bulbs were determined. These readings gave the amount of light of each wave-length absorbed, and by repetition, the rate of deposition during different periods of the lamp's existence. The entire set of photometric observations were duplicated, but since the final results

* Trans. Am. Inst. E. E., vol. vi, p. 293.

† Since the above was written an extended investigation upon this subject has appeared. It entirely confirms the results obtained by Mr. Pierce. (See "A life and efficiency test of incandescent lamps" by Prof. B. F. Thomas and Messrs. Martin and Hassler), Trans. Am. Inst. E. E., vol. ix. 1892.

‡ This Journal, vol. xxxvi, p. 332; also Phil. Mag., V, xxxii, p. 404.

obtained by the two independent observers (Moore and Ling), were in agreement, only the mean of the two sets is given in the following tables.

In order to ascertain precisely what part in the decadence of the lamp is attributable to the coating, it was necessary to keep careful watch of the continually shifting electrical and photometric conditions during its entire life; and in order to maintain in each lamp the precise conditions under which it had been determined that it should be burned, measurements of candle-power and voltage had to be made at short intervals, together with continual readjustments of the current.

Fourteen lamps in all were selected for the investigation. These were of two widely different types, representing the two great classes, viz: lamps with untreated and with treated filaments. Of these, some were maintained at the voltage indicated by the maker, or at predetermined, constant voltages other than this. Others were kept at constant candle-power throughout their entire life, the current being increased whenever the decrease in brightness due to increasing age had become appreciable.

From the data obtained in this way, the life curves of the various lamps were plotted, showing the variation in candle-power or voltage respectively, of resistance and of efficiency expressed in watts per candle, during its entire existence. Some of these curves have already been published.* As these results were quite in accordance with those obtained by Mr. Pierce, to which reference has already been made, it will be necessary to deal with them here only in so far as they bear upon the question of the influence of the age-coating upon the efficiency of the lamp.

I.

Color of the coating.

Measurements upon all fourteen of the lamps which were subjected to the spectro-photometric tests, showed the color of the coatings upon lamp-bulbs containing treated and untreated carbons, respectively, to be practically identical in character. The color of the coatings obtained in lamps of either type, under widely diverse conditions (as for example, by maintaining a sixteen candle-power lamp at sixty-four candles throughout its life), was the same as that produced under normal conditions of service. The color in question is very nearly neutral, the percentage of light transmitted being approximately the same for all parts of the visible spectrum. The effect of the

* The Artificial Light of the Future: Electric Club Pamphlets, No. 24, New York, 1890; also Electrical World, 16, p. 387, Electrical Engineer, 10, p. 595.

"*age-coating*," as the deposit which we are considering may be called, is therefore to dim the lamp, without appreciably changing the quality of its light.

The most complete set of observations obtained with lamps of untreated carbon are those referring to a lamp designated in our list as No. 2.* This lamp was maintained at normal voltage for over eight hundred hours. Frequent readings of candle-power and current, during this time, afforded the means of tracing the progressive changes of light-giving power, efficiency and resistance. Measurements of the age-coating were made after 100, 200, 400 and 800 hours of life, readings being taken in ten regions of the spectrum. The results are given in Table I, together with data indicating the condition of the lamp at the above mentioned periods of its life. These are taken from a set of sixty-seven readings of voltage and current, distributed over the entire life of the lamp at nearly equal intervals. The variation in voltage during the entire eight hundred hours was never more than 0·3 volts above or below the initial value.

TABLE I.

Lamp No. 2 (untreated filament).

Initial Conditions.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·8	0·474	214·8	16·00	3·015

Conditions after 100 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·9	0·453	225·3	12·50	3·697

Light transmitted by the coating, after 100 hours.

$\lambda =$ ·750	88·9 per cent	$\lambda =$ ·507	92·2 per cent
·713	90·2	·481	92·8
·635	91·8	·460	92·3
·658	91·5	·443	92·4
·538	91·9	·429	92.4

Conditions after 200 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·8	0·421	225·9	10·8	4·250

Light transmitted by the coating after 200 hours.

$\lambda =$ ·750	83·5 per cent	$\lambda =$ ·507	86·4 per cent
·713	84·5	·481	86·9
·635	85·6	·460	87·6
·580	85·4	·443	87·9
·538	85·9	·429	85·4

* This and other numbers used refer to the records of these experiments as given in full in the thesis of Messrs. Moore and Ling, a manuscript deposited in the library of Cornell University. (The Life and Duration of Incandescent Lamps; with special Reference to the Light absorbed by the Coating within the Bulb, by B. E. Moore and C. J. Ling. 1890.)

Conditions after 400 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·8	0·428	237·7	9·67	4·510

Light transmitted by the coating after 400 hours.

$\lambda =$ ·750	79·3 per cent	$\lambda =$ ·507	83·5 per cent
·713	80·9	·481	83·6
·635	82·3	·460	84·0
·580	82·0	·443	84·3
·538	82·6	·429	82·1

Conditions after 800 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
101·9	0·415	245·6	7·20	5·880

Light transmitted by the coating after 800 hours.

$\lambda =$ ·750	75·7 per cent	$\lambda =$ ·507	78·7 per cent
·713	75·9	·481	79·4
·635	78·0	·460	79·9
·580	78·6	·443	80·5
·538	78·4	·429	77·3

Another typical case was that of lamp No. 10, which was a lamp with a treated filament. It was maintained at a very different degree of incandescence, being a lamp of low efficiency, which when set at the voltage indicated by the manufacturer, required an expenditure of 5·16 watts per candle. The age-coating of this lamp approached even more nearly to complete neutrality of shade than did most of those which we had occasion to measure. The results obtained at two hundred and nine hundred hours are given in Table II.

TABLE II.

Lamp No. 10 (treated filament).

Initial Conditions.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
36·0	1·171	30·63	8·2	5·16

Conditions after 200 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
35·9	1·145	31·27	7·1	5·91

Light transmitted by the coating after 200 hours.

$\lambda =$ ·750	91·9 per cent	$\lambda =$ ·507	90·7 per cent
·713	90·4	·481	90·4
·635	89·5	·460	90·7
·580	90·5	·443	90·5
·538	90·5	·429	90·4

Conditions after 908 hours.

Volts.	Amperes.	Ohms.	Candle-power.	Watts per candle.
36·14	1·14	31·70	(unknown)*	

Light transmitted by the coating after 908 hours.

$\lambda =$ ·750	86·6 per cent	$\lambda =$ ·507	84·5 per cent
·713	85·2	·481	85·0
·635	83·1	·460	85·5
·580	83·6	·443	86·0
·538	84·5	·429	86·0

The normal life of a lamp starting at 5 watts per candle, is many thousands of hours. Lamp No. 10 was prematurely broken at 908 hours, at which time the coating had reached a density corresponding to that of a 3 watt lamp (No. 2) after 200 hours of life. A comparison of Tables I and II will show that while the coatings on these two lamp bulbs were not quite neutral nor precisely identical in tint, that they both transmit light with much greater uniformity than do such materials, for example as optical glass, calcite, etc.†

II.

The distribution of the age-coating within the bulb.

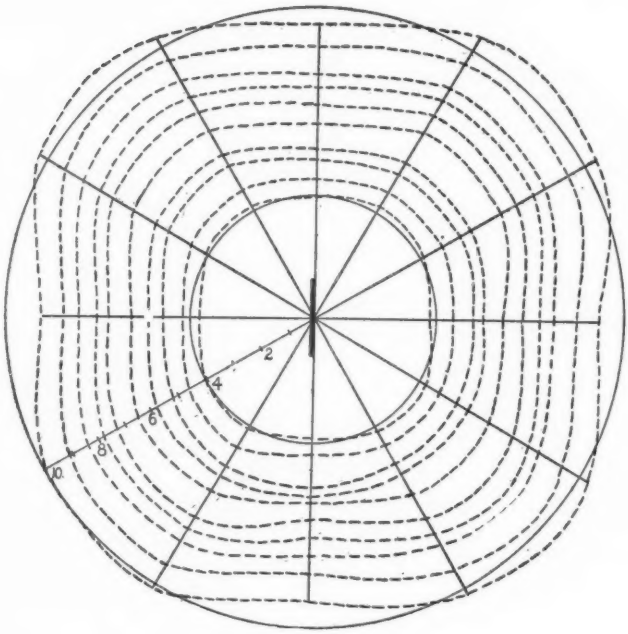
The distribution of the age-coating was determined indirectly, as follows: Two of the lamps under examination, were measured for horizontal candle-power according to the "Franklin Institute" method;‡ measurements being made in twelve meridians, 30° apart. The readings were repeated at frequent intervals throughout the life of the lamps. The results were plotted with polar coördinates. They show (figure 1), by the diminishing area of the successive curves, the progressive loss of brightness due to age, of which about one-half is ascribable to the coating. The similarity of the curves, from first to last, indicates that the coating is deposited uniformly within the bulb, or in uniform lateral zones, so that the density of the film, is symmetrical with reference to any given meridian. The case chosen for illustration is lamp No. 7. The results obtained with lamp 8, were in every essential respect the same as those shown in the diagram.

* The lamp was broken before the photometric measurements had been completed.

† See Kruess, Kolorimetrie, p. 243; also, Nichols and Snow, Phil. Mag., V, vol. xxxiii, p 379.

‡ See Franklin Institute Tests (International Electrical Exhibition, 1884), Philadelphia, 1885.

1.



III.

The age-coating considered as a factor in the diminishing efficiency of the lamp.

It may be seen from the Tables (I and II) that the absorbing power of the coating is in itself sufficient to account for a very considerable falling off in the candle-power, as the lamp, within the bulb of which it forms, grows old in service. By summation of the values in the tables, we may obtain the average absorbing power for the entire spectrum; and since selective absorption is almost entirely absent, these averages will give very closely indeed the loss in candle-power, which at the time in question was ascribable to the influence of the coating. From the data in Tables I and II, also, we may compute the efficiencies of the lamps at various stages in terms of their initial efficiency as unity; likewise their brightness from time to time, in terms of their initial candle-power, as unity. In Tables III and IV are given, for purpose of comparison, the relative brightness and efficiency of lamps 2 and 10, at

various periods, also the average absorbing power of their coatings.

TABLE III.

Relative brightness, efficiency and transparency of lamp No. 2, at various periods (each expressed in terms of its initial value taken as one hundred).

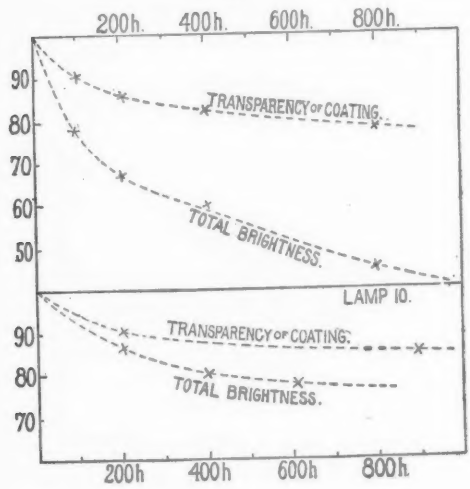
Time.	Relative brightness.	Relative efficiency.	Relative transparency of bulb.
000· hours	100·	100·	100·
100 "	78·1	81·5	91·44
200 "	67·5	70·9	85·91
400 "	60·4	66·8	82·46
800 "	45·0	51·3	78·24

TABLE IV.

Relative brightness, efficiency and transparency of lamp 10, at various periods (each expressed in terms of its initial value, taken as 100).

Time.	Relative brightness.	Relative efficiency.	Relative transparency of bulb.
0· hours.	100·	100·	100·
50· "	92·6	92·6	----
109· "	91·4	90·1	----
200· "	86·6	87·3	90·5
400· "	80·5	81·6	----
511· "	78·7	80·0	----
600· "	78·0	79·5	----
900· "	----	----	85·0

2.



The curves in figure 2 are based upon these data. They show that the loss in candle-power and efficiency are only in part due to the opacity of the coatings. It is of some interest to compare lamps 2 and 10, since the former is a three watt lamp, whereas the other required 5·16 watts per candle at the beginning of the test. It is to be regretted that the tests did not extend over the normal life-time of such a lamp; the results obtained, however, suffice to show that the loss due to coating is a much larger portion of the total loss in the low efficiency lamp than in the other. Measurements with several lamps, maintained at abnormally high temperatures seemed to indicate that the higher the state of incandescence the less marked (relatively) is the influence of the age-coating upon the decadence of the lamp.

Summary of results.

1. The rate of deposit of the coating in incandescent lamp bulbs is greatest in the early part of the life of the lamp. For example, in the case of a lamp which lasted 800 hours, (see Table III) more than half of the coating was deposited during the first 200 hours.

2. The loss of brightness due to the absorbing power of the age-coating is a variable part of the total loss, being greatest in lamps of high initial efficiency.

3. The coating does not appreciably modify the character of the light which emanates from the lamp.

4. The distribution of the coating within the bulb is a nearly uniform one (see figure 1).

5. No marked difference between treated and untreated filaments appears to exist, as regards the density or quality of the coating produced from them.*

Physical Laboratory of Cornell University, July, 1892.

*Since this article was written it has been pointed out by Professor B. F. Thomas (in the paper already cited), that in the case of lamps exhausted without the aid of mercury the age-coating is scarcely perceptible.

Art. XXXVII.—*Mica-peridotite from Kentucky;* by J. S. Diller.

In November, 1890, I received from Mr. E. O. Ulrich of the Geological Survey of Kentucky the information that a dike, called the Flanary dike, had been discovered in Crittenden County of that State. The specimens from the dike sent to me at that time for examination were laid aside awaiting the report upon the eruptive rocks of Arkansas by J. Francis Williams, and J. F. Kemp. It was expected that similar rocks would be found in Arkansas and this paper rendered unnecessary.

Mr. Ulrich has kindly furnished me the following information concerning the occurrence of the rock in the field.

The dike is in a fault striking N. 44 E. Although the peridotite has not yet been found all along the fault it is known to occur at four points on the line with a distance of 6 miles between the extremes. In Livingston county a little was seen in a shaft mixed with fluor spar and other vein matter. A mile and a half northeast of the county line and three miles from the locality just noted, a shallow opening exposes considerable decomposed peridotite of a light gray or ash color. Here again it is associated with vein matter chiefly fluor spar. At the Flanary shaft the dike is over 20 feet wide with no wall seen on either side. Crosscuts were made 6 feet on one side and 8 feet on the other without finding the walls. It may be that the shaft is at the intersection of several veins in a sort of "chimney." A quarter mile southeast on the Holly the vein matter is 6 feet solid and pure fluor spar. The dike break separates strata faulted no less than 800 feet with the St. Louis beds on the northwest and the upper Chester and coal-measure conglomerate on the southeast.

At least one other dike has been discovered in the county and Mr. Ulrich thinks its material is closely related to that of the Flanary dike. It occurs in a much tumbled region just south of the Columbia mines which he regards as the chief center of disturbance.

The specimens for my study were selected by Mr. Ulrich from among the material thrown out of the Flanary shaft. The shaft is 45 feet deep and the material exposed to surface weathering for nearly two years. The rock is dull greenish-gray. At first glance it has a granitic aspect but upon closer examination the resemblance disappears. It contains many small dark greenish spots besides brownish scales of mica. Upon comparing it with an altered specimen of the peridotite from Elliott county, Ky., one is led at once to suspect that

the dark green spots are serpentine and represent original olivine. A thin section of the rock examined under the microscope confirms the conjecture.

The rock is composed essentially of biotite, serpentine, and perofskite with a smaller proportion of apatite, muscovite, magnetite, chlorite, calcite and other secondary products which cannot be definitely determined. It is possible that originally there may have been some pyroxene present. The biotite is somewhat in excess of the serpentine and together they form nearly 75 per cent of the whole rock, small crystals of perofskite are abundant but their total mass is less than that of the brownish-gray clouded material supposed to be of secondary origin. Opaque black grains of magnetite are rather common and a few clear crystals of apatite as well as scales of chlorite and muscovite and small veins of fibrous calcite are present. Judging from the chemical analysis there is probably considerable chromite present also.

If we consider only the relation of the large scales of biotite to one another as determining the structure of the rock it is granitoid for the biotite is allotriomorphic. This mineral is yellowish brown to almost colorless. It occurs in round or oblong patches averaging about 4^{mm} in diameter and forms the groundwork of the rock. Within these irregular scales are scattered the crystals and grains of serpentine in such a way as to render them pœcilitic on a cleavage face. The biotite here plays essentially the same role as the hornblende and augite in the picrites. Between the larger scales, scattered here a few, and there many, throughout the brownish-gray clouded matter are smaller scales of biotite. In sections of the biotite perpendicular to its basal cleavage, although its colors between crossed nicols are brilliant its absorption is very feeble even less than that of ordinary brown hornblende. Prof. Rosenbusch suggests that the absorption is too small and the bisectrix too oblique for normal biotite. The biotite is occasionally altered to chlorite.

The serpentine is distributed uniformly throughout the rock in irregular rounded or angular grains averaging about 1^{mm} in diameter. The characteristic sections with outlines like those of olivine parallel to the base and macropinacoid are sufficiently numerous and well defined to clearly indicate that the serpentine originated from the alteration of olivine. The large quantity of olivine originally present shows that the rock belongs to the peridotites.

The mineral regarded as perofskite is abundant and generally well crystallized. The diamond-shaped, square and triangular sections which are completely isotropic demonstrate that it is isometric. Its color is honey-yellow and only moderately

transparent. The crystals vary in size from ·01mm to ·1mm in diameter and are almost always black-bordered. The chemical analysis of the rock shows that it contains 3·78 per cent TiO_2 with 9·46 per cent CaO. After taking out of the analysis the elements demanded for the other determined minerals there yet remains essentially the composition of perofskite. Titanic acid is frequently found in biotite and it is desirable that analyses be made of both biotite and perofskite in this case; but as the minute crystals of perofskite are generally enveloped by the biotite it would be very difficult and perhaps impossible to satisfactorily separate them.

The muscovite, chlorite, magnetite, apatite and fibrous calcite have no features deserving special mention. The brownish gray clouded material which is next in abundance to the serpentine is scattered throughout the section generally between the scales of biotite, but often within them. It is without crystallographic outline or such physical features as definitely indicate its origin.

The following chemical analysis of the rock for which I am greatly indebted to Mr. W. F. Hillebrand was made in the chemical laboratory of the U. S. Geological Survey.

SiO_2	33·84
TiO_2	3·78
Al_2O_3	5·88
Cr_2O_3	0·18
Fe_2O_3	7·04
FeO	5·16
MnO	0·16
NiO	0·10
CoO	tr.
CaO	9·46
BaO	0·06
MgO	22·96
K_2O	2·04
Na_2O	0·33
H_2O	7·50
P_2O_5	0·89
Cl	0·05
Fl	?
CO_2	0·43
	99·86

In addition to the water given, the sample lost 0·68 per cent water at 100° C. The large percentage of H_2O and CO_2 shows the highly altered condition of the rock.

Among the peridotites already described Rosenbusch has recognized six forms. Considering only their essential constit-

uents, the designations adopted by him are as follows:—*picrite* = olivine+augite, *amphibole picrite* = olivine+amphibole, *Wehrlite*=olivine+diallage, *Harzburgite*=olivine+rhombic pyroxene, *Lherzolite*=olivine+diallage+bronzite, *dunite*=olivine+chromite without pyroxene or amphibole.

Heretofore* no peridotitic rock has been recognized in which biotite† has played the rôle of an original essential constituent. While it is evident that the Flanary dike rock belongs to the peridotites, it is clearly excluded from any of the subdivisions above. In order that it may be conveniently distinguished from other peridotites I propose for it the name *mica-peridotite*, a name which I believe will at once suggest to all students of petrography its kinship.

More than half a decade ago Prof. A. R. Crandall‡ discovered the peridotite of Elliott county, Kentucky, and to this Mr. Ulrich now adds one more of the same type of rocks from the western part of the State. Closely related rocks of the same group have been described by Drs. J. C. Branner§ and R. N. Brackett from Pike Co., Ark., by Prof. G. H. Williams,‖ from Syracuse, N. Y., and by Prof. J. F. Kemp,¶ from Ithaca, N. Y.

A very fresh olivine mica rock closely related to the mica peridotite of Kentucky has been described by Dr. Max Koch,** who recognizes it as a new type. It occurs in the gabbro region of the Harz and contains augite and plagioclase as accessory minerals in small quantities. These minerals as well as the geologic relations of the rock indicate according to Dr. Koch, that it belongs to the gabbro group.

U. S. Geological Survey, Washington, D. C.

* Excepting perhaps one described by Max Koch which will be noticed later.

† The peridotitic rock described by Judd (Quart. Jour. Geol. Soc., Aug., 1885, p. 401), as scyelite is rich in mica; but he regards it as secondary resulting from the alteration of augite. Furthermore, scyelite contains hornblende of which not a trace has been found in the rock from Flanary dike.

‡ Geol. Survey of Ky., Report on the Geology of Elliott County, by A. R. Crandall, p. 17. See also articles by J. S. Diller, this Journal, Aug. 1886, and U. S. Geol. Survey, Bulletin No. 38.

§ This Journal, vol. xxxviii, p. 50, 1889; also, Geol. Survey of Ark. Annual Rept. for 1890, vol. ii, p. 377.

‖ Ibid., vol. xxxiv, pp. 140–142, 1887.

¶ Ibid., vol. xlii, p. 410, 1891.

** Zeitschr. d. d. geolog. Gesell., xli, p. 163, 1889.

ART. XXXVIII.—*Glaciation in the Finger-Lake region of New York;* by D. F. LINCOLN, M.D., Geneva, N. Y.

THE Appalachian plateau, at the line between New York and Pennsylvania, is composed of Upper Devonian sandstone and sandy shale, dipping slightly to the south, with summits 2000–2500 feet above tide level. The valleys are rather deep (400–800 feet), and resemble in a general way those of central Pennsylvania, but without the N.E.–S.W. parallelism of the latter. The elevations do not take the form of ridges; they consist of broad, clumsy masses, diminishing in steepness as they ascend, and capped with irregular rolling plains.

The Susquehanna, with its tributary the Chemung, here forms an important depression, north of which the land rises to the height of 2000 feet, again sinking to form the basin of the Finger Lakes. The lakes therefore occupy a section of the northern slope of the Appalachian plateau, which may be defined as extending 100 miles E.–W., from the Genesee Valley to Cazenovia Lake, and about 70 miles N.–S., from Lake Ontario to the curved line of high land just south of the lakes.

This line of heights corresponds in position with the "Terminal Moraine of the Second Glacial Epoch" of Chamberlin,* and is defined as a water-parting by the following high points—Bristol, 2254 ft.; Urbana, 1940; Orange, 2033; Newfield, 2095; Dryden, 1888; Virgil, 2133; Solon, 1977; Fabius, 2015; Fenner, 1862.†

The height of land of which these are the summits is cut through by many deep straight valleys, which on the south communicate with the Chemung-Susquehanna valley, while on the north they converge toward a common imaginary center in Lake Ontario. The northerly discharge is intercepted by streams flowing eastward, which unite to form the Oswego River. Most of these north-south valleys are so blocked with drift as to form lakes.

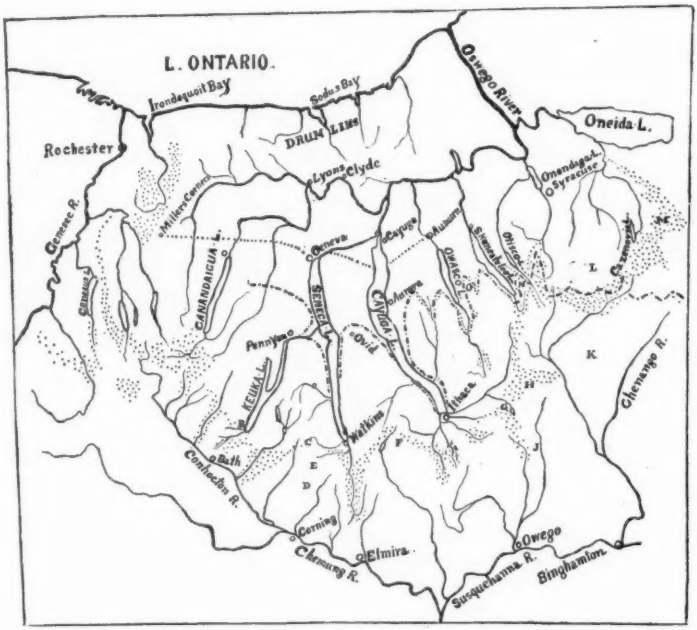
The middle of the common basin is axially depressed, in a north–south direction; the depression is occupied by the two largest lakes, Seneca and Cayuga.

There is a considerable system of minor, preglacial valleys still traceable in the elevated tracts between the lakes. This system, however, has been so disturbed by glaciation that it no

* U. S. Geol. Survey, Third Report.

† Triangulation of N. Y. State Survey, 1883, 1887.

longer furnishes in normal fashion a series of tributaries to the lakes. The greater part of the surface water enters the lakes through torrents, running from two to four miles in a straight course, at right angles to the lake-axis, through precipitous



The Finger-lake region of New York.

Terminal moraine (from Chamberlain) is represented by dots.—Corniferous limestone, a line of dots.—Tully limestone (Prof. H. S. Williams) dots and dashes — . — .

A, Bristol;	B, Urbana;	C, Sugar Hill;	D, Hornby;
E, Orange;	F, Newfield;	G, Dryden;	H, Virgil;
J, Richford;	K, Solon;	L, Fabius;	M, Fenner.

Elevations above sea-level—Rochester, 508; Lyons, 407; Clyde, 396; Bath, 1105; Elmira, 863; Sugar Hill, 2091; Hornby, 2045; Richford, 1995.

gorges, which they are still actively deepening. Some of the finest scenery in the State is found in these gorges. Watkins and Havana glens are examples; the highest waterfall in the State occurs in the Taughannock glen, near Ithaca; its perpendicular fall is 190 feet.

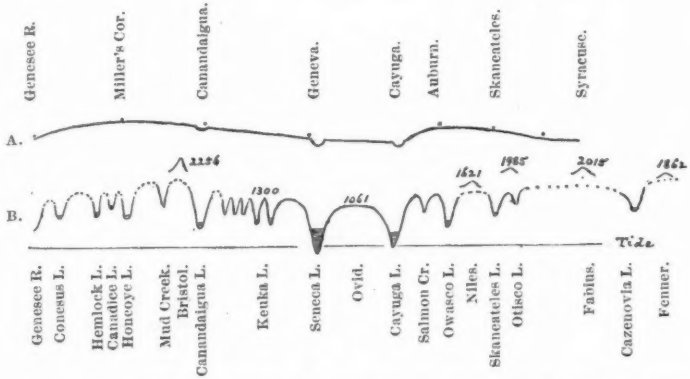
Altitudes and Depths of Lakes.

	Elevation above tide.		Greatest depth.
Erie	572·9	L	210 G
Chautauqua	1291	G	
Conesus	821	R	70 G
Hemlock	898	R	87 G
Canadice	1099	R	87 G
Honeoye	less than Hemlock		25 G
Canandaigua	668	G	
Keuka (Crooked)	718′ 10″	G	
Seneca	441	C	618 M
Cayuga	378	C	435 M
Owasco	670	G	
Skaneateles	860	G	
	864′ 12″		
	861	C	
Otisco	no data		
Cazenovia	900	G	
Schuyler	1200	G	
Otsego	1193	G	
Onondaga	361	G	
Oneida	369	G	
	367·71		
	368	C	
Ontario	246	L	738

L = U. S. Lake Survey. C = Resurvey of N. Y. Canals. R = Rochester Water Works Surveys. P = Penn. & N. Y. R. R. G = French's Gazetteer of N. Y., 1860 (comparatively poor authority.) M = Soundings given on map published by Engineering Department of Cornell University.

The entire basin may conveniently be divided into three regions or zones, nearly corresponding with certain geological formations. The northern zone (Silurian) is nearly *level*, with a heavy mantle of drift; it extends from the Ontario coast to the northerly escarpment of the Corniferous limestone, which is skirted by the line of railroad passing through Auburn, Geneva, Canandaigua, and Miller's Corners. The middle zone comprises the *moderate ascent* of the lower Devonian, extending south from 6 to 20 miles from the railroad. The southern zone, with *steep slopes* and deep valleys, comprises the Upper Devonian (Chemung and Portage rocks), including on the east the lower Devonian to Skaneateles. The zigzag dotted line of the Tully limestone partially indicates the demarcation between the two latter zones. The terminal moraine bounds the whole on the south.

The northern zone comprises the Medina, Clinton, Niagara, and Salina formations, dipping south at a low angle. The Clinton and Niagara limestones form escarpments facing north, which are inconspicuous in large part. It is traversed by the



A. Vertical section nearly E.-W. along N. Y. Central R. R., nearly on Corniferous outcrop.

B. Vertical section near the middle of each lake; dotted lines show deficiency of exact data, partially supplied by a few adjacent known points.

N. Y. Central R. R. and the Erie Canal at very easy grades. A portion along the southern edge of this belt is level and free from drift-hills: north of which the surface is diversified by an extraordinary series of drumlins, already described by Hall (New York State Geological Report for 4th Dist., 1842) and Johnson ("Parallel Drift Hills of Western New York;" Annals of N. Y. Acad. of Sci., Nov. 9, 1882). These are stated by Hall to be bounded northerly by the beach of the ancient Lake Iroquois—the "Ridge Road"—which runs a few miles from the shore of Lake Ontario.

As compared with the drumlins of New England, these are of much greater length, are relatively much narrower, much sharper at their ridges and steeper in their side-slope. Their northern ends are very bluff, their southern ends gently inclined. Their axes lie nearly north and south, on the whole, with marked local differences.

The width of these hills at top is often sufficient to receive a country road without much leveling, but some would not (in their original state) admit the passage of a single cart along the ridge; while in exceptional cases there are flat tops some hundreds of feet in width.

The inclination to the south is often so gentle as to have no definite ending; thus many hills which begin northwardly

with well-marked drumlin-outlines sink and broaden southwardly into plains of till. Some, however, are well-defined at both ends, and in length fall within one-half or two-thirds of a mile. Johnson states that the best developed ones run two or three miles, and reach the height of 100–200 feet above the plain; that they are highest and longest chiefly just south of the Niagara escarpment, though there are a few very high ones more to the south.

Measurements of a few of the steeper ones (kindly communicated by Mr. George H. Barton) show the inclination of the sides to be about 23°, and only exceptionally 25°.

The material of these hills is a till, possessing the usual characteristics—unless a tendency to the formation of very deep gullies (5–15 feet deep) on the sides be considered exceptional. Some are covered very thickly with good-sized traveled stones; some with sand or gravel of varying depth. In the neighborhood of Rochester are some of which the nucleus is sand, till forming the upper part. Considerable kame-deposits are associated with the drumlin-belt at some points, and near Rochester a portion of the moraine traverses it.

The writer's personal study of this region is limited to five localities, and the above statements are in part drawn from other sources. An excellent cursory view can be had from the car windows as the traveler passes east from Rochester on the main line of the N. Y. Central R. R. via Lyons and Clyde to Syracuse.

This belt of *large* drumlins practically comes to an end at the distance of twenty miles from Lake Ontario. Then come low lands, partly sandy, partly marshy. Still farther south, within the middle zone, the drumlin-formation is resumed, in ridges of much smaller height, but in considerable numbers. As this point has not met the writer's eye in print, attention is here called to it, and some special observations are offered.

Among the drumlins of the second range (in the middle belt) there are some which resemble the typical "lenticular hill" of New England. More, however, are of the ridge variety. And of the latter there are many grades, from the very well marked ridge with rather steep banks to very low ridges which are often so low and flat as to simulate terraces. The face of this part of the country is laid out in shallow grooves, often producing the strong impression of "fluting."

An instructive group of these ridges occurs in and around the town of Geneva. They are very nearly parallel, their axes lying between 10° and 15° west of north. The easternmost skirts the lake, and is somewhat eroded by the waters, displaying sections of till, with limited beds of blue clay and "quicksand." Its crest, on which Main street is built, reaches a height

of 90 feet above the lake. The other ridges increase in absolute elevation, but not in size, having an apparent height of 20–50 feet above the ascending slope which they cover. At somewhat over a mile from the shore they attain a height of 300 feet above the surface of the lake, which corresponds with the verge of the higher levels of land. Similar ridges are found for several miles farther west; sometimes crossing the road at pretty regular intervals of $\frac{1}{4}$ to $\frac{1}{8}$ mile, with elevations of only a few feet; at other times forming hills with a rather bold northern descent.

A distinct termination north and south can generally be traced in the ridges of the Geneva group, although the ordinary observer is inclined to overlook the fact. Their general outline, their material, and their tendency to steepness at the north end, ally them with the drumlins of the northern belt. The long ridge running west from the end of the lake is of typical till, with some large bowlders, overlaid in part by stratified sandy clay.

In this locality, the till evidently forms a continuous sheet, of which the ridges are merely a surface irregularity.

The slope of the sides of the ridges is about from 2° to 10° at Geneva, and their crests are occasionally from 100 to 300 feet wide.

The direction of the ridges of till as a whole is probably similar to that of the glacial striations, that is, convergent to a northerly point. At Clyde and Lyons (on the central axis of the region) they run a degree or two west of north. Near Cayuga, about N. 8° W.; and still further east, about 20° west of north.

The till at Geneva is a firm "hard-pan," containing a great number of subangular striated stones of all sizes up to three feet in length. The greater part of the stones are from the Corniferous limestone, which is exposed just north of the village. Of those representing more northern formations, many are water-rolled. The limestone fragments give a bluish tint to the otherwise reddish brown mass.

About three feet of the upper part of this till appears thoroughly oxidized and leached. This portion is a red clay, distinctly contrasted with the gray-blue till, and rather well demarcated. It is of a deep shade, unstratified, very tenacious, nearly free from sand; at times flaky, at times tending to split when dry into rectangular forms. It cuts with a slight grittiness; the surface is dotted with occasional specks of material not fully decomposed, which may represent some of the myriads of little bits of limestone found in the till. The stones are few, chiefly such as resist oxidation (quartzites); these correspond in appearance and amount with a simliar

ingredient of the till. Gneisses and schists are absent, or badly rotted. The forms are characteristic of till, and in some cases striation is observed. A part of the stones react feebly to HCl: the clay does not react.

Midway of the Cayuga lake shore, on the east side, there are fine till sections which give a similar result on analysis.

The same leaching of the upper part has been observed in stoneless sedimentary clay of Geneva. Absence of the lime-reaction is stated to be characteristic of the soil at the State Agricultural Station in the same town.

At many points on the surface of the lower-till (Drumlin) deposits just described, there is little or none of the englacial material defined by Upham.* But where the stones lie thickly in the fields it is necessary to suppose that they are chiefly of englacial origin; for the proportion of limestone fragments in such cases is quite too small to permit us to refer them to the lower-till. This is easily seen in the piles of stones which the farmers draw from the fields—sometimes 12–20 feet in diameter from a 100-acre lot—consisting mostly of gneissoids, schists, and quartzites, with perhaps one-fifth corniferous limestone, the lumps varying from 2 to 200 pounds in weight. The larger stones (bowlders) carry out this statement; they are almost all far traveled stones. Large bowlders are not very frequent. The largest within observation are one of labradorite (7×7 feet), and one of an argillaceous rock from the Salina beds (6×11) which is exceptional in having traveled only 5 or 6 miles.

Stratified deposits are not infrequent, however, upon the drumlin formation. Rolled gravel is not rare, and the kames and osars deserve a fuller description than can here be given.

On reaching the higher levels, west of Geneva or east of Aurora, we often find the surface sandy. The sand even takes the form of low hills and ridges. The deposit of tough lower-till, however, is still found beneath the light top-soil.

The thickness of the till-sheet at Geneva is reported at several points as 20–30 feet. Sand lies beneath this, and still lower, till again. At one well, there was 14 feet of sand, and 13 feet or more of the deeper till bed. Layers of vegetable matter, and blue clay, are also found.

In passing south from the soft shales of the Hamilton group to the sandy shales and hard fissile sandstones of the upper Devonian beds, we are informed of the change of bed-rock by the alteration in the character of the lower-till. The latter, in recent exposures, may be very tough, but is sandy rather than clayey. The enclosed stones are sandstone, rarely limestone. Fragments handsomely glaciated occur as large as three feet

* Amer. Geologist, vol. viii, No. 6.

long. The field-stones in this region split, losing their likeness to till-stones. Hence the "flat gravel," characteristic of the soil of the hilly districts.

The deltas of the lake sides are among the most conspicuous accumulations of drift material. Rising at intervals along the sides of the lakes and the southern continuations of their valleys, they attain by a series of steps the height of (?) 400 feet above the lakes. Their strata contain many stones which still show half obliterated glacial striæ.

The remainder of this paper will be devoted to certain points of preglacial topography and drainage, and the associated questions of amount of glacial corrasion, and bulk of drift-deposit. The northern zone, except as specially designated, will be omitted from consideration.

The deposits of the terminal moraine are very heavy; for a description of this feature the reader is referred to the paper on this subject by Thomas C. Chamberlin.

From considerable examination of the country included between the four larger lakes, the writer has been led to set a moderate estimate upon the amount of drift, and a very high estimate upon the amount of erosion in certain parts.

The lakes are to a great extent bordered by vertical cliffs of rock, with little or no beach at their foot. Owing to the greater prevalence of westerly winds the cliffs are best developed on the east side. In the case of Cayuga Lake this natural facility is aided by the presence of a railroad at the water's edge, for which in many places the cliffs have had to be cut. From Aurora southward for nearly 20 miles the top of the cliff is visible most of the way, undulating in very moderate curves, occasionally rising 50 feet or more, and at several points sinking below the level of the lake for short distances. In the latter case the rock is exposed in brooks a few rods inland. Till overlies this rock, varying in thickness from 2 to 40 feet. The till deposits along the east shore of Seneca lake are apparently not much in excess of the above.

It is probable that the rock-sections thus displayed correctly represent the general surface of the region as it would appear if the drift were removed. In some tracts, at all events, this is demonstrably the case. In the northern reaches of the lakes, hills of rock with a very flat curve correspond with these cliffs. A few examples may be worth describing. At the foot of Seneca Lake on the east side there is a line of cliff (Marcellus shale), which rises gradually to a height of 25–30 feet and extends more than a mile. A hill-side rises directly from the brow of this cliff to the height of about 90 feet; mainly rock with 2–20 feet of till. Three miles to the southward is another long shore-cliff of rather greater height, the land behind which

rises for 1½ miles eastward, reaching a height of 150 (?) feet, and forming a broad-backed N–S ridge of Hamilton shale covered with a couple of feet of drift. A third ridge 250 feet high, at a similar interval to the S.E., slopes very evenly to the lake (2½ miles distant) over rock covered with a very few feet of drift; in this case no cliff is formed, the rock not quite reaching the lake. The axis of this hill points N. 20°–30° W. On Cayuga lake, south of Aurora, there is a hill 300 feet in height, forming a cliff at the lake-side, two miles long and one mile across, with its long axis directed N.W.–S.E., composed of Hamilton shale. The top of this hill, for the length of a mile, forms a plateau. A smaller hill of Marcellus shale lies 4 miles to the north of this.

In the present state of the question it is admissible to suppose that these hills may be remnants of preglacial hills of bolder outline. The fact that they lie parallel to the lake need not militate against this view, since the old valleys of the region—farther south than the hills described—unite with the lakes and with each other at very acute angles.

The hills may constitute a very insignificant remnant of old hills; or may even have been carved out *de novo* from rock which occupied levels below the roots of their predecessors. In other words, the corrasion at the latitudes of Geneva and Auburn may have removed one hundred or several hundred feet. Definite evidence limiting these estimates is not before me. Apart, however, from the numerical estimate, it is interesting to note the parallelism between the axes of these hills and those of the drumlins which are found close by. Their material, a soft shale, yields readily to force applied horizontally, and it is not beyond the province of legitimate speculation to suggest that their forms may have been carved at the same time and in similar circumstances with the drumlins. Their bluffer northern sides, and their exceedingly gentle southern slopes, add much to the likeness.

A system of small valleys for local drainage, opening lakeward, doubtless existed before glaciation. We can point to no surviving representatives of these valleys at the lake level unless the slight depressions in the cliff line be taken as such. These descending curves run but a short distance below the lake level, and represent but slight inward bends of the rock-shore. If the lake were drained, the present mouths of the brooks flowing in these hollows would be a mile from the main stream which presumably occupied the axis of the valley. In going this mile they would fall from 300 to 600 feet. Such streams must have cut deep and wide gorges extending far inland. How deep some of these would have been at parts of the lake where the shores are bolder, may be estimated by considering

that the land at the upper part of Seneca lake rises in six miles to upland pastures nearly 2000 feet above the bed of the lake.* The continuity of cliffs for 15 miles along the west coast near Watkins, and the frequency of rock exposures on the high lands, forbid the belief that such gorges exist.

The inference from these considerations is that the preglacial river which has been developed into Seneca lake must have occupied a level many hundreds of feet above the present bed of the lake.

Some drift-buried valleys certainly exist. One such, probably with a meridional course, seems to lie to the east of Aurora, where two E.–W. ravines appear to cut it, one of which exhibits a till-section 100 feet thick, with bottom not reached. However this be, there still exists a large system of valleys, with banks several hundred feet high, subsidiary to the lake valleys and in several places communicating with them. These valleys are rock-cut, and often show rocky bottoms; they run mainly parallel to the lakes, but occasionally branch in a transverse direction. They run straight through the line of terminal moraine. Their trough-like aspect north of the moraine points to probable widening and deepening, as in the case of their much bigger brothers, the lakes.

As an illustration, take the large valley, 20 miles long, entering Cayuga lake 6 miles north of Ithaca. It is cumbered with some drift, but its walls rise 400 feet above its bed, in full sight from the lake.

Perhaps the case of certain upland valleys will add confirmation to these views. East of Watkins there is a system of these at 400–600 feet above the lake. The main drainage of this system is at present southward, but it communicates with the Seneca valley by two wide gaps, allowing several short streams to enter the lake, which they do by a sudden plunge—one of them cutting the beautiful Havana glen in its descent. These streams must have fallen 1,000 feet in three miles in order to have reached the Seneca valley bottom at its present level. In like manner the stream which has excavated the celebrated Watkins Glen descends about 500 feet in its last mile through a canyon with vertical walls, while its upper five miles are mostly in an old valley with moderate grades.

Again, Dundee, situated three miles from the west shore and ten miles north of Watkins, stands 600 feet above Seneca lake. It occupies a site apparently near the mouth of an old valley, bounded by rock-hills from 300 to 400 feet high, and displaying a rocky bottom in the stream at Dundee. The valley has four or five branches, extending six miles above the

*Seneca lake bottom is 177 feet below tide; high points W. of Watkins, near 2100 feet above tide.

village in several directions, with very moderate grades. In the direction of the lake the valley-sides become lower, and the valley itself disappears, debouching upon the lake side at an imaginary plane in mid-air. From this point the lake-side descends smoothly and rapidly, while the stream, with many cascades, falls 500 feet in two miles.

If these valleys, or any of them, had a preglacial existence, and a rational connection with the lake valley, it would seem necessary to suppose that the bed of the latter then stood at an elevation 800 (?) feet higher than at present. If they drained away from the lake, they would soon have been cut down by robber-streams falling into the Seneca valley. The present Chemung river valley, which would be the southerly exit, is 1200 feet higher than Seneca valley floor.

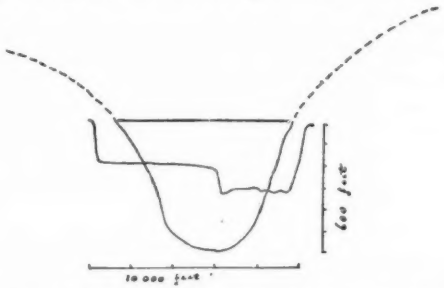
The trough of the present lake runs straight south from Watkins to the open valley about Elmira, 22 miles distant. The present bottom of the lake is 1,000 feet below the river at Elmira; a discrepancy which may be harmonized by either of two hypotheses,—glacial erosion of the lake bed, and filling of the valley at Elmira with overwash from the moraine. That the truth is a composite of both, seems very probable.

The belief that the lakes are deeply gouged by ice is consistent with the fact that their depth (in the case of the two largest) is much the greatest in the southern third. Considered relatively to the glacial movement, this is the downward part, and the fact agrees with Geikie's statements regarding the rock-cut lochs of western Scotland, which form basins, deepest toward their outlet. The section of Seneca lake along its axis is like that of an elongated tablespoon, pointed to the north. But until we know more about the depth of alluvial and drift deposit at the ends of the lakes, this consideration may be waived. It is nearly certain, however, that the lake bed is not more than 300 feet deep at Geneva where the apparent depth is 40 feet.

The direction of preglacial drainage may perhaps be inferred from the considerable and continuous slope of the land toward Lake Ontario. The height of land between this slope and that toward the Susquehanna system is near the south ends of the lakes, and it does not seem necessary to suppose that it was formerly placed much farther to the north. Such valleys as Seneca may have had their divide near the southern ends of the present lakes. A number of streams seem to have run southward across the divide; of which Keuka lake, and much of the distribution of the valleys about Canandaigua and Owasco lakes, offer strong suggestions.

Few borings have been made north of the lakes, and it is not advantageous to speculate upon a possible outlet for the

north-flowing streams. The lowlands north of Cayuga lake (Montezuma marshes) offer a very slight barrier to such a discharge. It is worth noting that a boring made at Geneva, at the lake side, encountered obstacles from bowlders at about 100 feet, and struck no true rock until 240 feet below the water line. A valley three miles wide between existing rock-exposures, and 300 feet deeper than the present lake surface, apparently opening to the north, is indicated at Geneva: some of this depth may be ascribed to glacial action.



Section of Channel of Wisconsin River (Report of U. S. Geol. Sur., VI, p. 230) partially filled with river-gravel; compared with that of Seneca Lake at deepest point. The latter section is adapted to scale from that given on the map published by Cornell University; the dotted slope of bank is obtained from contour-lines of map. Ratio of vertical to horizontal scale nearly = 10 : 1.

The accompanying cut is given to show the contrast between the much-glaciated banks of Seneca Lake, with thin smooth gentle curve leading to the upland levels, and the unglaciated banks of the Wisconsin River, falling at a sharp angle from the level of the plain in which the valley is cut. The section is from one of the narrower parts of the river, in its course through the non-glaciated region. The river valley is filled to an unknown but considerable depth with material brought from glaciated territory. The lake valley, judging from the outline given, is free from heavy glacial or postglacial deposits for many miles; its ends, however, are deeply filled.

ART. XXXIX.—*On Certain Points in the Interaction of Potassium Permanganate and Sulphuric Acid;* by F. A. GOOCH and E. W. DANNER.

[Contributions from the Kent Chemical Laboratory of Yale College—XVII.]

IN an article published some years ago by Mr. Francis Jones* upon the action of reducing agents upon potassium permanganate the statement is made that in the interaction of

* Jour. Chem. Soc., xxxiii (1878), p. 95.

oxalic acid and the permanganate in whatever way the conditions were varied—whether there was excess of oxalic acid or of permanganate, whether the solutions were strong or dilute, whether acid was present or not—in every case oxygen was obtained as a product of the reaction. The action between the permanganate and ferrous salts, in presence or absence of acids, in dilute or strong solutions, was said to yield oxygen similarly. In the discussion which followed the reading of this paper before the Chemical Society (London) some adverse comment seems to have been developed.*

More recently,† in developing his excellent volumetric methods for the estimation of tellurium, Professor B. Brauner has noticed a similar effect in the action of potassium permanganate upon tellurous oxide dissolved in sulphuric acid, and has shown, further, that in this particular case the evolution of oxygen is proportional to the amount of sulphuric acid employed, and that in working with alkaline solutions little evidence of such action appears.

The production of permanganic acid, and secondarily of free oxygen and ozone, by the action of strong sulphuric acid upon a permanganate is one of the commonest of phenomena, and the formation of a precipitate consisting largely of hydrated manganese dioxide by the action of hot dilute sulphuric acid upon the permanganate in aqueous solution is likewise well-known. It seemed desirable to us, therefore, to study further the action of sulphuric acid of different strengths upon the permanganate in solution, with a view to determining how far such action may be responsible directly or indirectly for the liberation of free oxygen in oxidations brought about in the presence of the acid. In the first set of experiments directed to this end we determined the amount of potassium permanganate remaining after exposure to the action of sulphuric acid during different intervals of time and under varying conditions of strength and temperature. The permanganate was used in approximately decinormal solutions (3·16 grms. to the liter) the exact strength of which was determined relatively to an approximately decinormal solution of oxalic acid. In fixing the standard small portions (usually 10 cm^3) of the oxalic acid were diluted to a volume of 100 cm^3 by means of sulphuric acid of two per cent strength by volume, the solution was heated to 70° C. or 80° C., and the permanganate was added as usual until the first permanent blush of color appeared.

The general mode of proceeding in the test experiments was, in brief, to mix the solution of permanganate with the sul-

* Ber. d. d. Chem. Gesell., 1878, p. 257.
† Jour. Chem. Soc., 1891, p. 238.

phuric acid (always previously diluted with an equal volume of water, and cooled) and, after the lapse of time indicated to add oxalic acid in quantity a little more than sufficient to bleach the entire amount of permanganate, warm to about 80° C., and titrate the residual oxalic acid by gradual addition of more permanganate. The difference between the amount of permanganate needed under the conditions to destroy the known amount of oxalic acid and that used in the determination of the standard should measure the oxygen lost by the permanganate under the action of the sulphuric acid. The results and details of these experiments are given below.

TABLE I.

H_2SO_4 [1 : 1] cm^3	Water. cm^3	$K_2Mn_2O_8$ in decinormal solution. cm^3	Percentage of H_2SO_4 [1 : 1] in solution during action.	Percentage of $K_2Mn_2O_8$ used as compared with that required by theory. cm^3
		A.		
		Treated immediately.		
2	8	10	10	100
4	6	10	20	100
6	4	10	30	101·5
8	2	10	40	101·6
10	--	10	50	101·9
		B.		
		Treated after standing eight hours at ordinary temperature.		
2	8	10	10	99·7
4	6	10	20	99·7
6	4	10	30	101·3
8	2	10	40	105·3
10	--	10	50	115·7
		C.		
		Treated after standing five days at ordinary temperature.		
2	8	10	10	104
4	6	10	20	121·6
6	4	10	30	149·7
8	2	10	40	155·9
10	--	10	50	156·4
		D.		
		Treated after standing one and one-half hours at 80°–90° C.		
2	8	10	10	101·3
4	6	10	20	143·8
6	4	10	30	135·9
8	2	10	40	149·1
10	--	10	50	155·3

It is manifest from an inspection of Table I that the decomposition of the permanganate increases directly in each series of experiments with the increase in the proportion of

sulphuric acid, that the amount of decomposition is greater as the time of action is extended, and that increase of temperature heightens the change. We note in particular, for example, that the presence of ten per cent of [1 : 1] sulphuric acid induces at the ordinary temperature no immediate decomposition of the permanganate, none in eight hours, and a breaking down amounting to four per cent in five days; and that the presence of fifty per cent of acid of the same strength occasions the decomposition of about two per cent at once, fifteen per cent in eight hours, and more than half the entire amount of permanganate in the course of five days. It is evident also that twenty per cent of the [1 : 1] acid produces no appreciable effect at ordinary temperatures and under exposures of a few hours only. The effect of heating the mixture of acid and permanganate to 80° C. for an hour and a half is closely comparable with that brought about by the five days action at the ordinary temperature.

In another series of similar experiments, the detailed record of which we omit as unnecessary, the absolute amounts of liquid and acid were increased while the proportion of the latter to the whole volume of the former was preserved. The volume of the liquid containing the acid and permanganate was fixed at 100 cm^3 and the absolute amounts of acid were taken five times as great as those used at corresponding points of the preceding series. The amounts of decomposition observed in these experiments followed those of the first series so closely as to compel the conclusion that it is the proportion of acid present rather than the absolute amount which is chiefly influential in the decomposition of the permanganate under given conditions. In still another series of experiments which differed from the last in the single point that the amount of permanganate used was increased five-fold no appreciable differences in effect which might be traced to such extra use of permanganate were discoverable.

It is, of course, possible, and even probable, that some decomposition of the permanganate by the sulphuric acid might be brought about after the addition of the oxalic acid during the warming of the mixture up to the temperature at which the oxalic acid and permanganate interact. The experiments of Table II were therefore undertaken to test this point. In them oxalic acid was replaced by a solution of ferrous sulphate in order to secure the removal of the residual permanganate at ordinary temperatures. The greatest care was taken to guard against atmospheric oxidation during the course of the experiment. The solution of ferrous sulphate was standardized before and after making the test experiments and found to be unchanged during the period of work. In

the first five experiments of series B the proportions of acid and liquid of series A were preserved while the absolute volumes were increased; in the last four experiments the range of variation in proportions was extended.

TABLE II.

H_2SO_4 [1 : 1] cm^3	Water. cm^3	$K_2Mn_2O_8$ in decinormal solution. cm^3	Percentage of H_2SO_4 [1 : 1] in solution during action.	Percentage of $K_2Mn_2O_8$ used as compared with that required by theory.
		A.		
		Treated at once.		
2	8	10	10	100
4	6	10	20	100·2
6	4	10	30	100·1
8	2	10	40	100·1
10	--	10	50	100·3
		B.		
		Treated at once.		
10	80	10	10	100·1
20	70	10	20	100·1
30	60	10	30	100·
40	50	10	40	100·5
50	40	10	50	101·3
60	30	10	60	103·
70	20	10	70	105·
80	10	10	80	103·3
90	--	10	90	108·1

The results of these experiments indicate, as was anticipated, that rather less decomposition of permanganate is caused by the sulphuric acid when the reduction of the residual permanganate is effected at ordinary temperatures. The increase in the amount of decomposition as the proportions of sulphuric acid [1 : 1] present are pushed beyond fifty per cent of the liquid is striking.

We have studied these same phenomena still further, varying, however, the mode of proceeding so as to observe and measure the gas evolved from the liquid as Jones* and Brauner* did in their individual investigations of the evolution of oxygen during oxidations. In these experiments tubes of suitable size and length, holding from 100 cm^3 to 200 cm^3, were sealed at one end, filled completely with the mixtures of acid and permanganate, inverted, and allowed to stand with the lower and open end submerged in liquid of the exact composition of that which filled them. The details and results of these experiments are recorded in Table III.

* loc. cit.

TABLE III.

A. $H_2SO_4[1:1] = 50$ per cent.

Time elapsed.	Gas from 100 cm³.	Appearance.
5 min.	0·1 cm³	No change.
1 hour.	1·1 "	No change.
1 day.	14· "	Red brown.
3 days.	15 3 "	Light brown.
4 "	15·6 "	" "
7 "		Brown, turbid.
8 "	16 "	Clearing by precipitation.
15 "	17·3 "	Clear, straw-colored.
17 "	17·4 "	" " "
35 "	17 5 "	" " "

B. $H_2SO_4[1:1] = 25$ per cent.

Gas from 100 cm³.	Appearance.
Small bubble.	No change.
9·6 cm³	Reddish purple. Turbid.
15·1 "	Reddish pink. Clearing by precipitation.
18 "	Nearly clear.
18·4 "	Clear and colorless.

C. $H_2SO_4[1:1] = 12·5$ per cent.

1 hour.	Small bubble.	No change.
1 day.	Bubble.	" "
3 days.	Bubble larger.	" "
14 "	7·1 cm³	Color lighter.
37 "	11· "	" "
44 "	12· "	" "

D. $H_2SO_4[1:1] = 6·25$ per cent.

Small bubble.	No change.
Bubble.	" "
Bubble larger.	" "
1 cm³	" "
3 "	" "
5 "	Little change.

The full amount of permanganate present in 100 cm³ of each mixture should, if reduced to the lowest condition of oxidation, be capable of liberating about 28·6 cm³ of oxygen, and every cubic centimeter of gas collected corresponds to 3·5 per cent of the entire quantity of available oxygen. In comparing the amount of gas liberated at once by 50 per cent sulphuric acid [1 : 1] (Table III, A) with the amount of reduction of the permanganate indicated under similar conditions (Table I, A) it appears that less than one-fifth (0·35 per cent) of the available oxygen of the permanganate which disappears in the action escapes solution and appears in free form. When, however, the comparison is made between the amount of gas liberated after four or five days (about 55 per cent of the total available oxygen) and the amount of reduction of the permanganate during a similar interval (Table I, C) the agreement is fairly close—within one or two per cent—the proportion of oxygen which goes to saturate the liquid being small relatively to the large absolute amount. It would seem to be evident that during this interval the breaking up of the permanganate resulted chiefly in its reduction to the lowest form of oxidation. After the seventh day in Exp. A, when a precipitate began to appear, comparatively little oxygen was set free; and on the thirty-fifth day, when the precipitation had ceased and the remaining liquid was straw-colored the amount of gas collected corresponded to about 61 per cent of

the available oxygen of the permanganate. The remaining 39 per cent must have gone with the precipitated oxide or have remained in solution as a higher sulphate. That but little of the higher sulphate did remain, however, is shown by comparison of A with B, in which after thirty-five days the liquid was entirely bleached. The gas finally set free in B amounted to 64·4 per cent of the available oxygen of the permanganate, and the remainder, 35·6 per cent, would be enough to throw down about 90 per cent of the entire amount of manganese in the permanganate in the degree of oxidation of MnO_2. It is noteworthy that the stronger acid, 50 per cent [1 : 1], still held some of the higher oxide in solution until the end, and that the acid of 25 per cent [1 : 1] allowed the decomposition to pass to completion in thirty-five days, while the smaller amounts of acid, 12·5 per cent [1 : 1] and 6·25 per cent [1 : 1], brought about in forty-four days decomposition amounting respectively to 42 per cent and 17·5 per cent respectively.

TABLE IV.

Percentage of H_2SO_4 [1:1]	Time elapsed. 1 day,	2 days,	3 days,	4 days,	5 days.	Percentage of $K_2Mn_2O_8$ decomposed.
10	Color unchanged.	Color unchanged.	Color unchanged.	Color unchanged. Slight sediment.	Color unchanged. Slight sediment. Slight scum.	103·6
20	" "	" "	" "	Color unchanged. Slight sediment.	Color unchanged. Slight sediment.	107·4
30	" "	" "	" "	Reddish tinge. Slight sediment.	Reddish tinge.	106·9
40	" "	" "	Tinged with reddish brown.	Reddish brown.	Reddish brown.	139·2
50	" "	" "	Reddish brown.	Reddish brown.	Red brown.	157·4
60	Color redder.	Color redder.	Reddish brown.	Sherry brown.	Reddish olive.	158·9
70	" "	" "	Sherry brown.	Reddish olive.	Reddish olive.	161·1

It seemed to be desirable in this connection to make the experiments detailed in Table IV, in which note is made of changes in color and formation of precipitates in 100 cm^3 portions of liquid containing 10 cm^3 of decinormal permanganate and varying proportions of acid during five days' standing,

the degree of decomposition of the permanganate being finally determined, as in the experiments of Tables I and II, by adding a small excess of oxalic acid to those mixtures contained in Erlenmeyer flasks, heating to about 80° C., and titrating with permanganate the residual oxalic acid.

In the first five experiments little change of tint was noted upon the addition of the oxalic acid to the cold solution, but in the last two experiments the reddish olive color became at once distinctly red—presumably because the higher sulphate of manganese was attacked in the cold by the oxalic acid (as Brauner has shown) and so the natural color of the permanganate was permitted to assert itself. The extreme decomposition—that which took place in the last experiment, in which 70 per cent of the [1 : 1] acid was present—corresponds nearly to the reduction of the entire amount of permanganate present to the condition of oxidation of MnO_2, which is known to exist in combination with sulphuric acid in the form of a higher manganic sulphate. It is to be noted that the separation of the insoluble higher oxide took place only when the percentage of acid was low.

It appears therefore, in brief, that when potassium permanganate and sulphuric acid are brought into solution together under the conditions which we have studied there is developed a tendency toward reduction on the part of the former which is the greater as the strength of the acid is increased, as the temperature is raised, and as the duration of action is extended. It appears further, at least when the acid is not present in proportion greater than 50 per cent of the [1 : 1] mixture, that in the early stages of the action the oxygen lost to the permanganate is liberated, and that later on the decomposition of the permanganate results in the precipitation of manganese in the form of a higher oxide or in the retention of the manganese in solution in the form of a higher sulphate. It is natural to suppose that the first effect of the mutual action of the acid and the permanganate is to set free permanganic acid, which, being unstable, breaks up with the results described.

The bearing of these observations and inferences upon the question of the action of potassium permanganate during oxidations carried on in the presence of sulphuric acid is obvious; for, if the aqueous acid is able to liberate permanganic acid in such proportions as to be spontaneously unstable, it is reasonable to presume that any reducing substance present at the time of such action may, by virtue of its attractive action upon the oxygen of many more molecules of the permanganic acid than would be necessary to supply the exact amount needed for perfect oxidation, tend to increase the general

instability of the already unstable molecules and so set up a far-reaching decomposition. It seems to us that these considerations throw some light upon the phenomena observed by Brauner* in the oxidation of tellurous oxide in presence of sulphuric acid; and the fact that the liberation of free oxygen in this special case is more noticeable than in the oxidation of ferrous salts or oxalic acid, for example, is explicable in the light of Brauner's observation that the attraction of tellurous oxide for oxygen is greatly inferior to that of these substances —not sufficient, in fact, to break up so unstable a substance as manganic sulphate, which is at once reduced by ferrous salts or oxalic acid. The practical lesson to be drawn is the desirability of keeping the acid present in oxidations effected by the agency of permanganate at the lowest limit consistent with perfect oxidation.

In Table V are recorded the results of a comparison made between Brauner's two excellent methods for the determination of tellurous oxide by titration with potassium permanganate—the one in alkaline solution, the other in acid solution—in which the precaution suggested as to the restriction of the amount of acid which should be present was taken. The tellurous oxide used in these experiments was prepared for the so-called pure crystallized element by oxidation with nitric acid and the prepared and ignited oxide was dissolved in potassium hydroxide.

In series A the alkaline solution of the oxide was diluted to 100 cm^3, potassium permanganate was added in excess, sulphuric acid [1 : 1] was introduced to an amount not exceeding by more than 5 cm^3 that needed for neutralization, oxalic acid was added in excess of the amount needed to destroy the manganic oxide and permanganate, the liquid was warmed to about 80° C., and the surplus of oxalic acid was titrated by permanganate.

In series B the alkaline solution of the oxide was treated with sulphuric acid [1 : 1] until the precipitate first thrown down was just redissolved, and 1 cm^3 of the same acid was added in excess. Permanganate was added in excess and oxalic acid in excess of the permanganate, the liquid was warmed, and titration by permanganate to the final reaction was completed as usual. In the calculation of the results the atomic weight of tellurium used by Brauner in his work† was adopted and the figures obtained correspond fairly well (without the application of any correction) with theory based upon this assumption. Our purpose, however, was simply to test the agreement between titrations made in alkaline solution and those carried out in acid solution.

* loc. cit. † loc. cit., p. 240.

TABLE V.

A.

	TeO_2 taken.	TeO_2 found.	Error.		Mean error.
(1)	0·1200 grm.	0·1199 grm.	0·0001 grm.	−	
(2)	0·0783 "	0·0783 "	0·0000 "		
(3)	0·0931 "	0·0938 "	0·0007 "	+	0·0006 grm.+
(4)	0·1100 "	0·1116 "	0·0016 "	+	
(5)	0·0904 "	0·0907 "	0·0003 "	+	
(6)	0·1065 "	0·1077 "	0·0012 "	+	

B.

	TeO_2 taken.	TeO_2 found.	Error.		Mean error.
(1)	0·0910 grm.	0·0912 grm.	0·0002 grm.	+	
(2)	0·0910 "	0·0908 "	0·0002 "	−	
(3)	0·0911 "	0·0922 "	0·0011 "	+	0·0003 grm.+
(4)	0·0913 "	0·0913 "	0·0000 "		
(5)	0·0912 "	0·0913 "	0·0001 "	+	
(6)	0·0914 "	0·0921 "	0·0007 "	+	

The agreement between the indications of the two methods is evidently close, and it is suggestive that that error which is slightly the larger, and also in the direction indicative of larger expenditure of the permanganate in producing the effect sought, is found on the side of the determinations made in alkaline solution.

As to the correlative question of the liberation of oxygen during oxidations by potassium permanganate in alkaline solution we have made no experiments, but experience (not detailed in this paper) in the collection of the gas liberated in oxidations effected in presence of acid leads us to distrust the evidence of such experiments unless the amount of gas liberated is considerable. While, on the one hand, small quantities of liberated gas may be so completely absorbed as not to appear free at all it often transpires, on the other hand, that the simple admixture of unlike liquids—such, for example, as a solution of potassium permanganate with sulphuric of strength insufficient to liberate oxygen—may bring about a very appreciable liberation of dissolved gases. So far as appears, however, the affirmation of the liberation of oxygen in oxidations by potassium permanganate in alkaline solutions now rests upon evidence of that nature only.

Art. XL.—*On the Crystallography of the Cæsium-Mercuric Halides;* by S. L. Penfield.

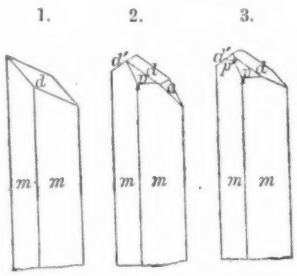
The salts to be described in this paper were prepared by Prof. H. L. Wells, and their chemical description has been given by him in the September number of this Journal.

The crystals were all measured on a Fuess reflecting goniometer, model II, and great pains were taken to select the best measurements as fundamental. In a few cases, where the crystals were very small and the reflections of the signal, therefore, rather broad, the mean of a series of measurements was used. The axial ratios are given in tabular form at the beginning of each separate chemical type and the fundamental angles, from which these are derived, are marked by an asterisk in the table of angles accompanying each salt.

Type 3 : 1.

	$\breve{a} : \bar{b} : \dot{c}$
Cs_3HgCl_5. Orthorhombic, monoclinic hemihedrism	0·7976 : 1 : 0·6605
$Cs_3HgCl_3Br_2$ " " "	0·7882 : 1 : 0·6527
Cs_3HgBr_5 " " "	0·7966 : 1 : 0·6656
Cs_3HgI_5, Orthorhombic, sphenoidal hemihedrism	0·5362 : 1 : 0·97975
or $\frac{3}{2}\breve{a} : \bar{b} : \frac{3}{2}\dot{c}$ =	0·8043 : 1 : 0·6532
$Cs_3HgBr_3I_2$ " " "	approximately like Cs_3HgI_5

The first three salts have exactly the same habit and crystallize in slender prisms, attached at one end and terminated at the other by faces which are arranged with monoclinic symmetry, figs. 1, 2 and 3. The crystals were seldom over 1mm in diameter, but the faces were perfect and admitted of accurate measurement. The forms and angles are:



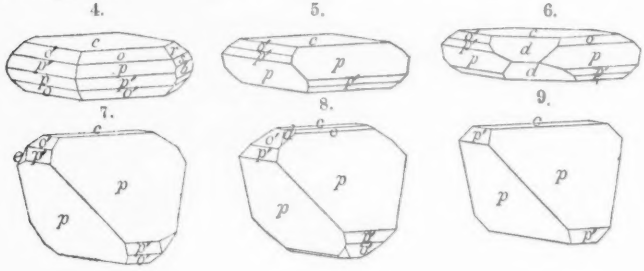
m, 110, I	d', $0\bar{1}1$, $'1\text{-}\breve{\imath}$	p, 111, 1
d, 011, $1\text{-}\breve{\imath}$	e, 021, $2\text{-}\breve{\imath}$	p', $1\bar{1}1$, $'1$

	Cs_3HgCl_5		$Cs_3HgCl_3Br_2$		Cs_3HgBr_5	
	Measured.	Calculated.	Measured.	Calculated.	Measured.	Calculated.
$m \wedge m$, $110 \wedge 1\bar{1}0$ =	*77° 9′		76° 33′	76° 30′	*77° 5′	
$m \wedge p$, $110 \wedge 111$ =	*43 21		*43 29		*43 6½	
$m \wedge p$, $1\bar{1}0 \wedge 111$ =	80 41	80° 41½′			80 37	80° 36½′
$m \wedge d$, $110 \wedge 011$ =	69 55	69 54	70 14	70 13	69 49	69 48
$m \wedge e$, $110 \wedge 021$ =	60 8	60 11			60 10	60 7
$d \wedge e$, $011 \wedge 021$ =	19 29	19 26	19 28	19 25		
$d \wedge d'$ $011 \wedge 0\bar{1}1$ =	66 53	66 53½	*66 16		67 16	67 18
$d \wedge p$, $011 \wedge 111$ =	34 39	34 39	34 37	34 44	34 47	34 49

The crystals have orthorhombic optical properties. When lying on their prismatic faces all show in polarized light an extinction parallel to the vertical axis, and in convergent light a trace of the ring system can be seen, indicating that the plane of the optical axes is the base.

We have here an excellent illustration of monoclinic hemihedrism in the orthorhombic system. Among all of the crystals which were examined, there was not one which had a holohedral termination. The forms d' and p', when present, were always smaller than the corresponding forms d and p, while e was only observed to the right above. Also the right handed vertical edge of the prism showed a tendency toward a skeleton-like growth, which was not observed to the left. In measuring the crystals great pains were taken to detect a monoclinic character by the angles, but none could be found. Of course the three salts may be regarded as monoclinic, with an angle β, differing so little from 90° that it can not be detected by the goniometer, but against such a supposition are the arguments, that the crystals have orthorhombic optical properties and, while there is a variation in the axial ratios of the series as bromine is substituted for chlorine, there is no change in the angle β, as would be expected if the salts were monoclinic. In this connection it is interesting to note that while the chloride and bromide are very similar in their axial ratios, the chemically intermediate chloro-bromide is not crystallographically intermediate.

At the present time there seems to be no other known compound which illustrates this hemihedrism. Different substances, which have been referred to this class, as datolite or wolframite, for example, have been shown by accurate measurement, or a study of their optical properties, to be truly monoclinic. Professor P. Groth, in the last edition of his Physikalische Krystallographie, has not mentioned this hemihedrism as a possibility in the orthorhombic system, although in the former edition of his work and in most treatises on crystallography it is recognized.



The different crops of Cs_2HgI_5 which were examined showed a great variety in habit, represented by figs. 4–8. The hemihedral development is not always strongly marked, and forms like figs. 5 and 6 are the commonest. The crystals sometimes measured over 5^{mm} in diameter and gave excellent reflections.

Only one crop of $Cs_2HgBr_2I_2$ was examined. The crystals were in the form of sphenoids, fig. 9, some of them over 10^{mm} in diameter, but the faces were curved and striated and only approximate measurements could be made.

The forms which were observed are:

b, 010, *i*-$\bar{1}$	*d*, 102, $\frac{1}{2}$-$\bar{1}$	*s*, 021, 2-$\bar{1}$	*p'*, 1$\bar{1}$1,–1	*o'* 1$\bar{1}$2,–$\frac{1}{2}$
c, 001, 0	*r*, 011, 1-$\bar{1}$	*p*, 111, 1	*o*, 112, $\frac{1}{2}$	*e*, 1$\bar{2}$1,–2–$\breve{2}$

The angles of Cs_2HgI_5 are:

		Measured.	Calculated.			Measured.	Calculated.
				c ∧ *o*,	001 ∧ 112 =	46° 1′	46° 2′
c ∧ *p*,	001 ∧ 111 =	*64° 15′		*o* ∧ *o'*,	112 ∧ 1$\bar{1}$2 =	39 55	39 46
p ∧ *p'*,	111 ∧ 1$\bar{1}$1 =	*50 23		*o* ∧ *o'*,	112 ∧ 11$\bar{2}$ =	87 57	87 56
c ∧ *r*,	001 ∧ 011 =	44 23	44° 25′	*o* ∧ *d*,	112 ∧ 102 =	19 50	19 53
c ∧ *s*,	001 ∧ 021 =	62 58	62 58	*p* ∧ *e*,	1$\bar{1}$1 ∧ 1$\bar{2}$1 =	17 48	18 4

Both Cs_2HgI_5 and $Cs_2HgBr_2I_2$ cleave distinctly, parallel to the base, but the crystals are very brittle and usually break with a conchoidal fracture. Crystals of the former, which are tabular parallel to the base, show in convergent polarized light a bisectrix normal to *c*, 001; the plane of the optical axes is the macro-pinacoid and their divergence is large.

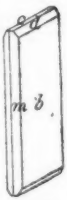
Type 2 : 1.

		a : *b* : *c*	
Cs_2HgCl_4	not measured.		
Cs_2HgBr_4	Orthorhombic	0·5706 : 1 : 1·4715	
$Cs_2HgCl_2Br_2$	"	0·567 : 1 : ---	
$Cs_2HgCl_2I_2$	"	not measured.	
Cs_2HgI_4	Monoclinic	1·3155 : 1 : 0·9260	$\beta = 69° 56'$
$Cs_2HgBr_2I_2$	"	Approximately like Cs_2HgI_4	

The crystals of Cs_2HgCl_4 were too thin to measure.

Both Cs_2HgBr_4 and $Cs_2HgCl_2Br_2$ crystallize in thin rectangular plates; those of the former were sometimes several centimeters long, but seldom over $\frac{1}{2}$^{mm} thick, and had the habit shown in fig. 10. The crystals of the latter salt were very much thinner. The plates were often grouped, with the large pinacoid faces slightly divergent, and isolated crystals, suitable for exact measurement were only occasionally found.

10.



The forms which were observed on Cs_2HgBr_4 are:

b, 010, *i*-$\bar{1}$ *c*, 001, *O* *m*, 110, *I* *d*, 011, 1-$\bar{1}$ *p*, 221, 2

and on $Cs_2HgCl_2Br_2$, *b*, *m* and a second prism 130, *i*-$\breve{3}$. The end faces could not be made out.

The angles of Cs_2HgBr_4 are:

	Measured.		Measured.	Calculated.
$m \wedge m$, $110 \wedge 1\bar{1}0$	$= *59° 25'$	$m \wedge p$, $110 \wedge 221$	$= 33° 58\frac{1}{2}'$	$33° 58'$
$b \wedge d$, $010 \wedge 011$	$= *34\ 12$			

On this salt the dome d is always small and frequently wanting. The pyramid p was only observed on a few crystals. In convergent polarized light a bisectrix may be seen normal to b, 010. The plane of the optical axes is the macro-pinacoid and their divergence is so large that they cannot be measured in air but in α-monobromnaphtaline the following values were obtained:

$2H = 80° 12'$ for yellow, Na flame.
$2H = 85\ 23$ for red, Li flame.

The dispersion is strong $\rho > v$. The acute bisectrix is axis of least elasticity, the double refraction is therefore positive.

The only angles on $Cs_2HgCl_2Br_2$ which were measured are:

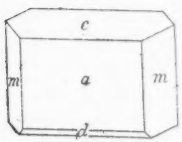
$m \wedge m$, $110 \wedge 1\bar{1}0 = *59° 6'$ and $110 \wedge 130 =$ approx. $30° 53'$, calculated $30° 59'$

In convergent polarized light a bisectrix may be seen normal to b, 010. The plane of the optical axes is the macropinacoid, and their divergence is large. The axis of greatest elasticity is normal to b.

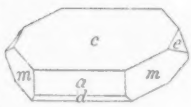
Only very fine needles of $Cs_2HgCl_2I_2$ were obtained, which were too small for measurement. These appeared under the microscope as striated prisms, with their obtuse edges rounded by oscillatory combinations. In polarized light they show a parallel extinction and in convergent light a biaxial interference figure, the plane of the optical axes being the vertical pinacoid. The acute bisectrix is axis of least elasticity.

The crystals of Cs_2HgI_4, which were frequently several cen-

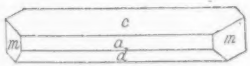
11.



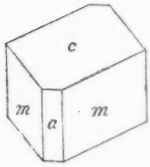
12.



13.



14.



timeters in diameter, showed a variety of habits represented in figs. 11, 12 and 13. The crystals of the latter habit are usually attached at one end and taper toward the free extremity, owing to a tendency to develop vicinal pyramids in the zone d–b.

The crystals of $Cs_2HgBr_2I_2$, which were examined, were about 2^{mm} in diameter and had

the simple habit shown in fig. 14. The faces were rounded and uneven so that only approximate measurements could be made.

The forms and angles are:

a, 100, i-$\bar{i}$	*c*, 001, *O*	*d*, $\bar{2}01$, 2-$\bar{i}$
b, 010, i-i	*m*, 110, *I*	*e*, 011, 1-$\bar{i}$

	Cs_2HgI_4 Measured.	Cs_2HgI_4 Calculated.	$Cs_2HgBr_2I_2$ Measured approximately.
$c \wedge a$, 001, $\bar{1}00$	= *69° 56′		66° 41′ to 66° 47′
$m \wedge m$, $110 \wedge \bar{1}10$	= *77 58		77 16 to 77 57
$a \wedge d$, $\bar{1}00 \wedge \bar{2}01$	= *41 25		
$c \wedge e$, $001 \wedge 011$	= 40 55	41° 1′	

The cleavage of both salts is perfect parallel to the base, less so parallel to the clinopinacoid. With Cs_2HgI_4 the plane of the optical axes is at right angles to the symmetry plane and clinopinacoid cleavage sections show in convergent polarized light an obtuse bisectrix, which is axis of least elasticity. The axis of greatest elasticity makes an angle of about 50° with the vertical axis in the acute angle β.

Type 1 : 1.

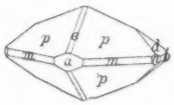
				$a : b : c$
$CsHgCl_3$	Isometric and	Orthorhombic		0·57735 : 1 : 0·40884
$CsHgClBr_2$	"	"	"	approximately like the above.
$CsHgBr_3$	"	"	Monoclinic	1·0124 : 1 : 0·70715, $\beta = 87° 7'$
$CsHgBrI_2$			"	0·978 : 1 : 0·743 , $\beta = 87° 3\frac{1}{2}'$

$CsHgI_3$ not measured.

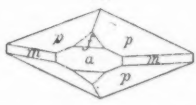
The first three compounds are dimorphous and, from solutions containing an excess of alkali halide, they all crystallize in cubes. These sometimes have their edges truncated by small dodecahedron faces, less often beveled by 210, i-2. The crystals show a slight action on polarized light and give an extinction parallel to the diagonals of the cube, but this anomaly is probably due to some internal tension, for when crushed the fragments are isotropic. No cleavage could be detected.

$CsHgCl_3$ was repeatedly recrystallized from water and always two types were observed. One of these was confined to those crystals which were attached to the sides of the beaker, while those which grew more in the interior had an entirely different habit. The crystals of the first type averaged about 2^{mm} in greatest diameter and had the habit shown in figs. 15 and 16. The forms and angles are as follows:

15.



16.



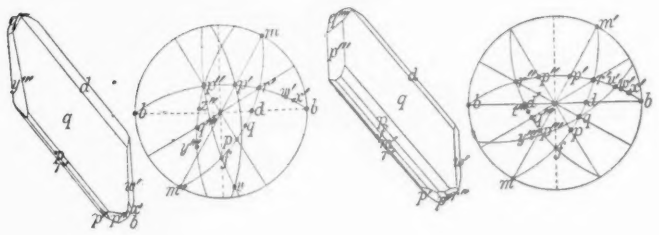
a, 100, i-$\bar{1}$ | *m*, 110, I | *e*, 101, 1-$\bar{1}$ | *d*, 021, 2-$\breve{1}$
b, 010, i-$\breve{1}$ | *n*, 130, i-$\bar{3}$ | *f*, 201, 2-$\bar{1}$ | *p*, 111, 1

	Measured.	Calculated.			Measured.	Calculated.
$m \wedge m$, $110 \wedge 1\bar{1}0 =$	*60° 0′		$a \wedge p$, $100 \wedge 111 =$	56° 45′		56° 45½′
$d \wedge d$, $021 \wedge 02\bar{1} =$	*101 27½		$m \wedge p$, $1\bar{1}0 \wedge 111 =$	71 33½		71 33
$p \wedge p$, $111 \wedge \bar{1}11 =$	66 28½	66° 29′	$p \wedge d$, $111 \wedge 021 =$	36 54		36 54
$p \wedge p$, $111 \wedge 1\bar{1}1 =$	36 54	36 54	$a \wedge e$, $100 \wedge 101 =$	54 42½		54 42
$m \wedge p$, $110 \wedge 111 =$	50 43½	50 43⅔	$a \wedge f$, $100 \wedge 201 =$	35 13		35 13½

The crystals were brilliant and gave wonderful reflections. The prismatic angle was measured repeatedly and found to be 60° and the forms *could* be referred to the hexagonal system, making the *m* and *b* faces a prism of the first order, *a* and *n* a prism of the second order and *p* and *d* the unit pyramid. There was nothing, however, in the development of the faces to suggest hexagonal symmetry. Thin sections were prepared, hoping that the optical properties would throw some light upon the form, but they showed only a very weak double refraction, in fact they appeared almost like isotropic sections, so that no satisfactory conclusions could be drawn.

The crystals of the second type were spear-head shaped, fig. 17, and grew out into the center of the solution, either attached to one another by the acute solid angles, or to a slender, parallel growth of crystals, which served as a sort of stem. The crystals which are about 5^{mm} in length are complicated and perplexing, and the faces are developed with triclinic symmetry, although they can be referred to the axes of the first type. The most prominent faces are shown in the figure, while the distribution of all those which gave distinct reflections are given in the spherical projection, fig. 18. The forms which were observed are given as if they belonged to a triclinic crystal and are:

17. 18. 19. 20.



b, 010, i-$\breve{1}$ | *p*, 111, 1′ | *q‴*, 1$\bar{3}$2, ′$\frac{3}{2}$-$\breve{3}$ | *y‴*, 7$\bar{5}$5, ′$\frac{3}{8}$-$\breve{\frac{5}{8}}$
m′, 1$\bar{1}$0, ′I | *p′*, $\bar{1}$11, ,1 | *r′*, $\bar{1}$31, ,3-$\breve{3}$ | *z″*, $\bar{1}$57, ,$\frac{5}{7}$-$\breve{9}$,
f, 201, ′2-$\bar{1}$′ | *p″*, $\bar{1}\bar{1}$1, 1, | *w*, $\bar{1}$91, ,9-$\breve{9}$ | *v*, 1131, 11$\frac{1}{3}$′
d, 021, 2-$\breve{1}$′ | *q*, 132, $\frac{3}{2}$-$\breve{3}$′ | *x′*, $\bar{1}$151, ,15-$\breve{15}$

The crystals gave excellent reflections and only occasionally a slight striation interfered with making accurate measurements. All of the forms were observed on two crystals and probably others could have been found by measuring a larger number.

The crystals of $CsHgClBr_2$ have a similar habit, fig. 19, and the distribution of all of the faces which gave distinct reflections is given in the spherical projection, fig. 20. This salt is more insoluble than the chloride and the crystals are consequently much smaller, not over $1\frac{1}{2}^{mm}$ in greatest diameter. All of the forms given above for the chloride were observed except *z* and *v*, and in addition:

d' $0\bar{2}1$, '2-∞ *p'''*, $1\bar{1}1$, '1 *r''*, $\bar{1}31$, 3-$\frac{3}{2}$ *u'*, $\bar{1}71$, 7-$\frac{7}{1}$ *t*, $2\bar{1}27$, '$\frac{1}{2}$-$\frac{2}{7}$

The crystals gave very good reflections, considering their size, and the best measurements agreed so well with those of the chloride that no attempt was made to calculate a new axial ratio. The most marked difference in the two salts is the development of the zone *p'' z'' q''' y'''* in the chloride and *r''' d' t''' q''' p''' f* in the chlorobromide.

The measured and calculated angles are as follows:

			CsHgCl₃	CsHgClBr₂	Calculated.
m' ∧ *f*,	$1\bar{1}0$ ∧ 201		44° 45′	45° 6′	44° 58½′
f ∧ *p*,	201 ∧ 111		26 35	26 27	26 34½
p ∧ *q*,	111 ∧ 132		18 27	18 34	18 27
q ∧ *d*,	132 ∧ 021		18 26	18 23	18 27
d ∧ *r*,	021 ∧ $\bar{1}31$		26 44	26 26	26 34½
x ∧ *r*,	$\bar{1}151$ ∧ $\bar{1}31$		33 40	33 20	33 40½
w ∧ *r*,	$\bar{1}91$ ∧ $\bar{1}31$		26 36½	26 27	26 33
u ∧ *r*,	$\bar{1}71$ ∧ $\bar{1}31$			21 35	21 47½
r ∧ *p'*,	$\bar{1}31$ ∧ $\bar{1}11$		26 33	26 37	26 34½
p' ∧ *p''*,	$\bar{1}11$ ∧ $\bar{1}\bar{1}1$		36 52½	36 37	36 54
b ∧ *r''*,	$0\bar{1}0$ ∧ $\bar{1}\bar{3}1$		44 44		44 58
y''' ∧ *q'''*,	$7\bar{5}5$ ∧ $1\bar{3}2$		22 13		22 13
z'' ∧ *p''*,	$\bar{1}97$ ∧ $\bar{1}\bar{1}1$		28 38		28 35
q''' ∧ *p''*,	$1\bar{3}2$ ∧ $\bar{1}\bar{1}1$		50 54		50 49
y''' ∧ *q*,	$7\bar{5}5$ ∧ 132		62 29½	62 22	62 28½
p'' ∧ *v*,	$\bar{1}\bar{1}1$ ∧ $\bar{1}\bar{1}3\bar{1}$		60 46		60 45
p' ∧ *v*,	$\bar{1}11$ ∧ $\bar{1}\bar{1}3\bar{1}$		66 53		66 59
f ∧ *p'''*,	201 ∧ $1\bar{1}1$			26 38	26 34½
p''' ∧ *q'''*,	$1\bar{1}1$ ∧ $1\bar{3}2$			18 23	18 27
q''' ∧ *d'*,	$1\bar{3}2$ ∧ $0\bar{2}1$			18 34	18 27
t''' ∧ *d'*,	$2\bar{1}27$ ∧ $0\bar{2}1$			10 13	10 19
q ∧ *w*,	132 ∧ $\bar{1}91$		50 59	51 4	50 46
q ∧ *p'''*,	132 ∧ $1\bar{1}1$			50 50	50 49
q ∧ *q'''*,	132 ∧ $1\bar{3}2$		60 3		60 4

It will be seen from the spherical projection that the forms of $CsHgClBr_2$ lie mostly in three zones, suggestive of hexagonal rhombohedral symmetry, although there is nothing in the arrangement of the faces, and still less with $CsHgCl_3$, to indicate that this is correct. The crystals of $CsHgClBr_2$ have

a slightly stronger action on polarized light than those of $CsHgCl_3$. When lying on the large q faces, both show an extinction parallel to the edges between p, q and d.

On a crystal of $CsHgCl_3$ the faces in the zone p, q, d, r made prisms, which served for the determination of the following indices of refraction.

Prism of 36° 54′, 021 ∧ $\bar{1}\bar{1}\bar{1}$, n, γ, Na flame = 1·791 n, r, Li flame = 1·779
Prism of 63° 28½′, $\bar{1}31$ ∧ $\bar{1}\bar{1}\bar{1}$, n, γ, " " = 1·792 n, r, " " = 1·779

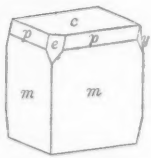
The crystal was of course very small and the refracted rays were not very bright, but the latter were well defined and the double refraction was not strong enough to separate them into two distinct rays.

The author cannot give any satisfactory explanation of these curious forms. They seem to illustrate a tetartohedral development of the faces of an orthorhombic crystal, resulting in a figure with triclinic symmetry. The mathematical relations have been very carefully determined and the facts given. It is hoped that a further study will throw some light on the subject.

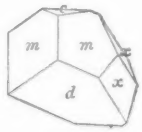
The different crops of $CsHgBr_3$ which were examined showed a variety of habits, represented by figs. 21, 22 and 23.

21.

22.



23.



The forms and angles are as follows:

c, 001, 0	e, 201, − 2·$\bar{1}$	o, $\bar{1}11$, 1	y, 261, − 6·$\bar{3}$
m, 110, I	d, $\bar{1}01$, 1·$\bar{1}$	p, 221, − 2	x, $\bar{1}31$, 3·$\bar{3}$

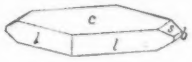
	Measured.		Calculated.	
$c \wedge m$, 001 ∧ 110 =	*87°	58½′		
$c \wedge d$, 001 ∧ $\bar{1}01$ =	*35	52		
$c \wedge e$, 001 ∧ 201 =	52	28½	52°	30½′
$c \wedge o$, 001 ∧ $\bar{1}11$ =	45	40	45	49

	Measured.		Calculated.	
$m \wedge m$, 110 ∧ $1\bar{1}0$ =	*90°	38′		
$d \wedge x$, $\bar{1}01$ ∧ $\bar{1}31$ =	60	41	60°	40′
$e \wedge p$, 201 ∧ 221 =	38	46	38	46½
$e \wedge y$, 201 ∧ 261 =	67	21	67	28

The crystals are seldom over 5^{mm} in diameter and sometimes have a hemimorphic development, although this is not always apparent. In the prevailing type, fig. 22, there is perhaps a tendency for 221 to predominate over $2\bar{2}1$ but this is not great. The pyramids x and y were observed only with hemimorphic development, fig. 23. The crystals were tested for pyro-electricity but no satisfactory results were obtained,

which is perhaps owing to their small size. The crystals of $CsHgBrI_2$ were about 2^{mm} in diameter and had the habit shown in fig. 24, which is quite different from that of the bromide. The forms and angles are as follows:

24.



b, 010, i-$\bar{i}$ $\quad$ c, 001, 0 $\quad$ l, 320, i-$\frac{3}{2}$ $\quad$ s, 034, $\frac{3}{4}$-$\bar{i}$

	Measured.		Measured.	Calculated.
$l \wedge l$, $320 \wedge 3\bar{2}0$	$=$ *66° 8′	$l \wedge s$, $320 \wedge 034$	$=$ *72° 22′	
$b \wedge s$, $010 \wedge 034$	$=$ *60 54	$l \wedge s$, $\bar{3}20 \wedge 034$	$=$ 76 16	76° 50′

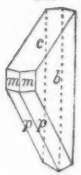
The basal planes were curved and uneven so that no satisfactory measurements could be made from them, and the other faces, although bright, did not give very satisfactory reflections. The crystals show in convergent polarized light an optical axis, almost normal to the base, the plane of the optical axes being the clinopinacoid.

Type 2 : 3.

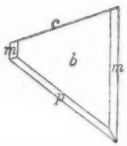
$a : b : c$

$Cs_2Hg_3I_8$. Monoclinic, hemihedral. $0{\cdot}3438 : 1 : 0{\cdot}3544$, $\beta = 71° 55\frac{1}{2}'$

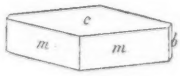
25.



26.



27.



The crystals of this salt have a curious development. Some of the most conspicuous forms are triangular plates, fig. 25, while fig. 26 is a projection of the same upon the clinopinacoid. These crystals are terminated above by a basal plane and below by pyramidal faces, which gives a curious hemimorphic development in the direction of the symmetry plane. A variety of habits was observed, long prismatic, skeleton forms and simple shapes like fig. 27, but in almost all of these the hemihedral character was prominent. The crystals frequently measured over 10^{mm} in greatest diameter. The faces were bright and gave excellent reflections. The forms and angles are as follows:

b, 010, i-$\bar{i}$ $\quad$ c, 001, 0 $\quad$ m, 110, I $\quad$ p, $11\bar{1}$, 1

The pyramid was observed only with hemihedral development.

	Measured.		Measured.	Calculated.
$c \wedge m$, $001 \wedge 110$	$=$ *72° 51′	$m \wedge p$, $110 \wedge 11\bar{1}$	$=$ *50° 26′	
$m \wedge m$, $110 \wedge 1\bar{1}0$	$=$ *36 12	$b \wedge p$, $010 \wedge 11\bar{1}$	$=$ 74 17	74° 14′

Two cleavages were observed, one perfect parallel to the clinopinacoid, a second less perfect parallel to the base. In polarized light clinopinacoid tables give an extinction, inclined about 23° to the vertical axis in the acute angle β. Basal plates show in convergent light an optical axis not far removed from the center of the field. The plane of the optical axes is the clinopinacoid.

These crystals furnish an excellent illustration of inclined faced hemihedrism, as recently developed by Prof. Geo. H. Williams,* who has shown that it is of frequent occurrence on pyroxene.

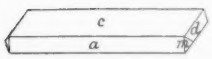
Type 1 : 2.

		a	$:b:$	c	
$CsHg_2Cl_5$,	Monoclinic	1·6099	: 1 :	1·3289,	$\beta = 78° 54'$
$CsHg_2ClBr_4$	Orthorhombic	0·586	: 1 :	-----	
$CsHg_2Br_5$	"	0·590	: 1 :	1·15	

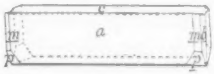
$CsHg_2I_5$, not measured.

$CsHg_2Cl_5$ was made in slender lath-shaped crystals, over 10^{mm} long in the direction of the symmetry axis but not over $\frac{1}{2}^{mm}$ in diameter. Fig. 28 represents a simple, and 29 a twin crystal, with the orthopinacoid as twinning plane. The forms and angles are as follows:

28.



29.



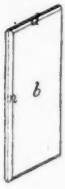
a, 100, i-$\bar{i}$	c, 001, O	d, 011, 1-$\bar{i}$
b, 010, i-i	m, 110, I	p, 111, -1

Two orthodomes were also identified, $\bar{1}01$ and $\bar{2}01$, but they were very small and yielded only approximate measurements.

		Measured.			Measured.	Calculated.
$a \wedge c$.	$100 \wedge 001 =$	*78° 54′	$c \wedge m$,	$001 \wedge 110 =$	84° 5′	84° 5′
$a \wedge m$,	$100 \wedge 110 =$	*57 40	$m \wedge p$,	$110 \wedge 111 =$	31 12	31 8
$c \wedge d$,	$001 \wedge 011 =$	*52 31	$a \wedge p$,	$100 \wedge \bar{1}11 =$	58 4	58 3
			$b \wedge p$,	$010 \wedge 111 =$	47 19	47 19

The plane of the optical axes is at right angles to the symmetry plane and the obtuse bisectrix is nearly normal to the base.

30.



Both $CsHg_2ClBr_4$ and $CsHgBr_3$ were made in rectangular tablets, fig. 30, which were not over $1\frac{1}{2}^{mm}$ in greatest diameter and were very thin. Twins were common, with the unit prism as twinning plane, and the plates often penetrated at angles of about 60° and 120°, reminding one of little cerussite twins.

* This Journal, xxxviii, p. 115, 1889.

The forms and angles are as follows:

$CsHg_2ClBr_4$	$CsHg_2Br_5$
b, 010, *i*-$\bar{1}$	*b*, 010, *i*-$\bar{1}$
m, 110, *I*	*n*, 120, *i*-$\bar{2}$
d, 011, 1-$\bar{1}$	*d*, 011, *i*-$\bar{1}$
	e, 014, $\frac{1}{4}$-$\bar{1}$

	Measured.	Calculated.
$m \wedge m$, $110 \wedge 1\bar{1}0$ =	*60° 44′	
$b \wedge b$, twin =	60 35	60° 44′

	Measured.	Calculated.
$b \wedge b$, twin =	*61° 5′	
$b \wedge d$, $010 \wedge 011$ =	*41 0	
$b \wedge n$, $010 \wedge 120$ =	40 20	40° 17′
$b \wedge e$, $010 \wedge 014$ =	73 25	73 57

Type 1 : 5.

		a : *b* : *c*	
$CsHg_3Cl_{11}$,	Monoclinic	0·7233 : 1 : 0·4675	β = 85° 51′ 40″
$CsHg_3ClBr_{10}$	"	0·7111 : 1 : 0·4561	β = 85 29

31.

The chloride was made in prismatic crystals, fully 10^{mm} long, and having the habit shown in fig. 31. The forms and angles are as follows:

m, 110, *I* *d*, 011, 1-$\bar{1}$ *e*, $\bar{1}$01, 1-$\bar{1}$ *f*, 101, −1-$\bar{1}$

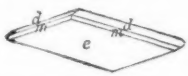
The dome *f* was usually wanting.

	Measured.	Calculated.
$m \wedge m$, $110 \wedge 1\bar{1}0$ =	*71° 37′	
$d \wedge d$, $011 \wedge 0\bar{1}1$ =	*50 0	
$m \wedge e$, $1\bar{1}0 \wedge \bar{1}01$ =	*66 8	
$d \wedge e$, $011 \wedge \bar{1}01$ =	41 21	41° 20½′

	Measured.	Calculated.
$m \wedge d$, $110 \wedge 011$ =	72° 31′	72° 31′½
$m \wedge d$, $\bar{1}10 \wedge 011$ =	78 49	78 48
$d \wedge f$, $011 \wedge 101$ =	39 30	39 29½
$e \wedge f$, $\bar{1}01 \wedge 101$ =	65 43	65 42

The chlorobromide $CsHg_5ClBr_{10}$ is much more insoluble than the chloride and was made in crystals, which were not over $\frac{1}{2}^{mm}$ in greatest diameter. The habit is shown in fig. 32 and is very different from that of the chloride. The forms and angles are as follows:

32.



m, 110, *I* *d*, 011, 1-$\bar{1}$ *e*, $\bar{1}$01, 1-$\bar{1}$

	Measured.		Measured.	Calculated.
$m \wedge m$, $110 \wedge 1\bar{1}0$ =	*70° 40′	$d \wedge e$, $011 \wedge \bar{1}01$ =	*40° 58′	
$d \wedge d$, $011 \wedge 0\bar{1}1$ =	*48 54	$m \wedge d$, $110 \wedge 011$ =	72 40	72° 40′

The crystals are strongly double refracting and the little tables show in convergent polarized light a bisectrix nearly normal to *e*. The plane of the optical axes is the clinopinacoid and the optical axial angle is small. The interference phenomena are very interesting when observed through colored glasses. In the hyperbola position the figure is almost uniaxial when viewed through red glass, while with blue the hyperbolæ are separated, probably as much as 15°–20°.

Sheffield Scientific School, New Haven, June, 1891.

ART. XLI.—*On Silver Hemisulphate;* by M. CAREY LEA.

THE existence of those substances which I described some years ago under the name of photosalts of silver* necessarily implied the existence of the hemihaloids of silver also, as these latter entered into the composition of the photosalts. Similar inferences, though less definite, had long been drawn from the action of light on silver haloids. Two of these, the chloride and bromide, lost by the action of light their complete solubility in ammonia without becoming completely soluble in nitric acid. Evidently there was indicated an intermediate compound between the normal haloid and metallic silver. During the last ten or twelve years I have devoted much time to the attempt to isolate these lower compounds of silver and to gain some certain knowledge as to the hemioxide, whose existence seemed almost a necessary inference from that of the hemihaloids. Some eight years ago, I obtained a substance having all the properties which one would be disposed to ascribe to Ag_2Cl and a large number of analyses made seemed to confirm the view. I hesitated, however, to publish a description of it, not feeling entire certainty that it might not be a mixture, as to which a concordance of the proportions found of Ag and Cl with theory gives no sufficient information. Since then M. Guntz has described a subchloride obtained by acting on silver hemifluoride with phosphorus pentachloride and a hemioxide derived from it. Up to the present time no combination of silver hemioxide with an oxyacid has been known.

Such a combination I have been able to obtain as a double salt of hemisulphate and normal sulphate containing one molecule of each. The new salt has a light bright brown color, and exhibits a stability which in view of its composition, is something remarkable. It has no tendency either to oxidation or to reduction. Nitric acid, unless very strong, has but little action upon it. Acid of 1·42 poured over it in large excess and let stand for several days gradually dissolves it completely, but the same acid diluted with with two or three times its volume of water has so little action that it forms a convenient means of purification. On the other hand, ferrous sulphate which instantly reduces argentic sulphate has no action whatever on the new substance even with several days' contact. Hot strong sulphuric acid has no action. It might almost be expected that under its influence, the argentous salt would gradually take up oxygen and be converted into argentic sul-

* This Journal, xxxiii, May and June, 1887.

phate. But a specimen which was covered with a large excess of undiluted sulphuric acid in a flask and was kept under boiling water for ten hours was not altered thereby. Another strong proof of its stability is found in its resistance to heat.

The application of heat produces a somewhat curious succession of colors. The terra cotta or warm brown shade of the moist substance changes by drying above 100° to pale lilac, at 165°–170° it becomes grayish, at a somewhat higher temperature, yellowish green. Considerably below red heat it acquires a fine ruby red color. In cooling, this red darkens almost to black, then becomes lighter again and when cold the color is light olive-green. The changes are repeated as often as the substance is heated and cooled. No sulphuric acid vapors are disengaged even at a low red heat.

It was mentioned in a previous paper that when silver nitrate is reduced by solutions of phosphorous or hypophosphorous acid or by acidified solutions of their alkaline salts, transient colorations were produced that seemed to suggest the presence of some form of 'allotropic silver. Since that paper was published this reaction has been taken up for further study. It soon appeared that when the silver salt was treated with a solution of alkaline hypophosphite, acidified with sulphuric acid, the result obtained was entirely different from that which presented itself under any other circumstances. It became clear that sulphuric acid did not act solely by setting free the hypophosphorous acid, but also acted on the silver with formation of a double sulphate.

A remarkable though limited analogy here presents itself between the substance just described and the photosalts of silver. The silver hemihaloids are very unstable substances, but acquire stability by uniting with the normal haloids. In the same way the hemisulphate, which is not known to be capable of separate existence, becomes perfectly stable by union with the normal sulphate. The limitation to this analogy lies in the fact that the last mentioned combination occurs in definite proportions, which does not seem to be the case with the halogen compounds.

The new substance then is formed by the joint action of sulphuric and hypophosphorous acid on a silver salt. Hypophosphorous acid has but little action on silver sulphate already precipitated, but it is different when the silver sulphate is formed in presence of hypophosphorous acid.

Several silver salts may be used. I have at different times employed the nitrate, phosphate and carbonate. The latter is perhaps the best, because the action with the nitrate is too rapid, and with the phosphate, too slow, and for other reasons.

A weighed quantity of silver nitrate is precipitated with an excess of alkaline carbonate and washed. The carbonate, as well as all the other reagents employed must be absolutely free from chlorides, otherwise the product becomes contaminated with silver chloride which cannot be removed. The silver carbonate is then treated with a solution of alkaline hypophosphite acidified with sulphuric acid. All the alkaline hypophosphite of commerce contains much more than a trace of chloride: this is best got rid of by adding to its solution a little solution of silver nitrate, stirring well at intervals, letting stand for twenty-four hours and filtering. This filtrate with addition of sulphuric acid is to be poured over the moist silver carbonate and constantly stirred. The reaction is complete in twenty or twenty-five minutes, when a bluish-black film of reduced silver begins to form on the surface. Further action is then cut short by neutralizing the liquid with alkaline carbonate. The precipitate is next to be washed several times by decantation. Very pure distilled water is, of course, needed throughout.

Convenient proportions are: 40 grams silver nitrate precipitated with excess of alkaline carbonate. Of sodium hypophosphite, 100 grams, dissolved in 650 c. c. of water are treated with a little silver nitrate, and after standing and filtering, 4 c. c. of sulphuric acid are to be added and the liquid poured over the silver carbonate. After a few minutes, 6 c. c. more of sulphuric acid, diluted with a little water, are added by degrees. With this second quantity of sulphuric acid the characteristic reddish-brown color of the substance first appears.

This process may be varied by precipitating with disodic phosphate (which must be perfectly free from chloride) instead of alkaline carbonate. The action is much slower, about 24 hours being needed. Silver nitrate itself may be used, but the action is too rapid and the product is less in quantity.

The crude product obtained in either way is to be purified with nitric acid. Acid of 1·42 is diluted with three times its volume of water, and of this dilute acid a quantity is taken about double in volume to that of the precipitate and of the water left after decanting closely. After a time some effervescence takes place, but the mixture does not become warm. After standing for three or four hours over the precipitate, it is to be poured off and the precipitate washed. This treatment with acid is applied three times: the first removes a good deal of silver, the second a little, the third a trace. Each time the acid is left three or four hours in contact. The product is then washed by pouring on it a large quantity of boiling water. This is repeated four or five times, each time (except

the first) placing the vessel in a water bath kept at 100° C. for several hours.

The product is either dried in the air or (for analysis) at 100° C. It forms a bright brown substance, permanent in the air, changing to violet when kept for some time at 160° C. It has the peculiarity that when water is poured on it, it makes a sharp hissing noise. This takes place with the air-dried substance as well as that dried at higher temperatures and as much with the former as with the latter.

The substance after purification has about one-half the weight of the silver nitrate taken.

These proportions and this mode of operating are those that I have found to give the best result. But the substance is formed under a great variety of conditions. It seems impossible to bring a silver salt into contact with alkaline hypophosphite acidified with sulphuric acid without producing more or less of it. Its presence is often completely obscured by reduced silver. But a mass which looks perfectly black and might be supposed to contain nothing but metallic silver will leave, when treated with nitric acid, a bright brown residue of the double sulphate. We have here, as before, an analogy with the photosalts. For it will often happen that a blackish mass, containing metallic silver and mixed or combined silver chlorides will, when treated with nitric acid, resolve itself into bright purple or rose colored photochloride.

All the specimens of this new substance contain a little phosphoric acid which cannot be removed. Reckoned as phosphoric anhydride it amounts to a little over two per cent. Three determinations gave respectively, 2·30; 2·09; 2·18, mean 2·19.

It is apparently united with silver and this silver phosphate is united so firmly with the double sulphate that it cannot be detached. If it were not so united it would be dissolved in the nitric acid with which the substance is three times treated if it were normal phosphate, and if it were hemiphosphate it would be converted (if in a free state) to normal phosphate and dissolved.

Another attempt to remove this phosphate was made by heating the substance with sulphuric acid to 100° C. for ten hours, followed by copious treatment with boiling distilled water to wash out the sulphate which it was hoped would be formed at the expense of the phosphate. It seems difficult to believe that a silver phosphate could resist this treatment, but a quantitative determination showed that the proportion of phosphoric anhydride is not even diminished by it.

Other modes of formation than those described here were experimented on with the view of obtaining the substance free from phosphate, but without good result.

It is possible that the silver phosphate may be combined in definite proportions and the approach to uniformity of composition somewhat favors this idea. But such a view would require the assumption of a large, perhaps too large a molecule.

Analyses.

A. Material prepared from silver carbonate and dried at 100° C.

	(1)	(2)	Mean.
Ag	76·13	76·75	76·44
O	3·29	....	3·29
P_2O_5	2·30	2·09	2·19
SO_3	16·19	16·47	16·33
Water	1·78	....	1·78
	99·69		100·03

B. Material prepared by various other methods considered less reliable.

Determinations.

Ag per cent.	P_2O_5.	SO_3.	O.
78·59			3·93
78·45			3·69
77·16			3·61
75·43	2·18	15·61	3·29
75·46			3·25
75·35	1·77		
Mean 76·74			Mean 3·55

The determinations of phosphoric and of sulphuric anhydride are placed opposite the silver determinations to which they belong. The oxygen determinations are distinct.

The most reasonable interpretation of these results is that we have to do with a double sulphate of silver hemioxide and protoxide in which a portion of the sulphuric acid is replaced by phosphoric. The proportion of phosphoric acid seems to be nearly constant, three concordant analyses having given 2·09, 2·30, and 2·18, with a mean of 2·19. These proportions may be expressed by the formula

$$7(Ag_4SO_3Ag_2SO_3H_2O) + Ag_6PO_4Ag_3PO_4.$$

The comparison of this formula with results obtained is as follows:

	Calculated.	Found (Mean).
Ag	76·79	76·44
SO_3	15·67	16·33
P_2O_5	1·98	2·19
O	3·80	3·29
H_2O	1·76	1·78
	100·00	100·03

This large molecule results from the relatively small proportion of P_2O_5, and although the figures obtained for phosphoric anhydride are very concordant, it perhaps is better to consider the substance as a double sulphate in which part of the sulphuric acid is liable to be substituted by phosphoric. If the silver phosphate is taken as adventitious, the formula becomes simply Ag_4SO_4, Ag_2SO_4, H_2O.

Decompositions.—The action of alkaline hydroxides is confirmatory of the above conclusions, and also offers further proof of the great stability of the substance.

When the double salt is placed in contact with excess of dilute sodium hydroxide it blackens, being converted into a mixture of the hemioxide which is intensely black, and the normal oxide. This decomposition, however, takes place much more slowly than with the salts of the protoxide, so that (unless heat has been applied), if after ten or fifteen minutes the alkali is poured off and the oxides are dissolved with dilute nitric or sulphuric acid a considerable residue is found of the red-brown double salt which has escaped decomposition.

With continued treatment with sodium hydroxide (that obtained from metallic sodium was used as being absolutely free from chlorine, the decomposition is complete.

The oxide thus precipitated was thoroughly dried at 160°–170° C., weighed and ignited. Five determinations of oxygen from various specimens gave 4·73; 4·63, and again 4·24; 4·19; 4·17 per cent of oxygen respectively. A salt with the constitution already described should yield one molecule each of hemioxide and of normal oxide, and this mixed oxide should contain 4·68 per cent of oxygen. We have then:

	Mean of 5 determinations.	Calculated.
Oxygen per cent.	4·39	4·68

The double salt is more readily decomposed by hydrochloric and hydrobromic acid or even by alkaline chlorides or bromides. Under their action it instantly blackens. That part of the silver that exists in the form of hemisulphate is converted into black hemichloride or hemibromide. The extreme instability of these hemihaloids causes them sponta-

neously to resolve themselves into metal and normal haloid. They rarely remain as hemihaloid for more than an hour or two, and often for much less time. The change is often quite sudden and is easily observed by the alteration of color, the black of the hemihaloid passing into the metallic gray color belonging to a mixture of normal haloid with metallic silver. The hemibromide seems to be a little less unstable than the hemichloride.

This instability does not render an analysis impossible since both the products of the change are insoluble; but renders it somewhat more difficult, as the freshly formed silver haloid tends to run through a filter. Sometimes indeed it seems as if traces of the silver chloride were for a few moments soluble in water with a yellow coloration. The appearance of this yellow color in the water is apt to be the first indication of the splitting up of the hemichloride.

Two analyses were made, one of material obtained by acting on the brown salt with dilute hydrochloric acid; this contained 81·79 per cent of silver. One by decomposing it with sodium chloride; this gave 81·93 per cent. A substance having the formula already given should, by conversion into chloride, give a mixture in which two-thirds of the silver should exist as hemichloride, and one-third as normal chloride. We have then—

	Found.			
	1.	2.	Mean.	Calculated.
Ag per cent..	81·79	81·93	81·86	82·35

a result sufficiently close to afford a confirmation of the constitution assigned.

When the brown salt is decomposed with dilute hydrobromic acid or an alkaline bromide, a corresponding result is obtained. By treatment with hydrobromic acid a mixed bromide resulted which proved to contain 66·06 per cent of silver.

A general consideration of all the reactions which I have obtained seems to indicate that the action of sulphuric acid and sodium hypophosphite on silver carbonate does not lead directly to the production of the double salt which I have described, but that the hemisalt is produced in excess, often in large excess; that the nitric acid oxidizes this excess, being able to attack the *free* hemisalt, but not that portion which is combined with protosalt and so rendered stable. It follows that whatever has been the original relative proportion between the two salts the nitric treatment leaves always one molecule of each. If it were possible to control the formation it is not improbable that a pure hemisulphate might

be obtained. But the action of the hypophosphite tends so strongly to carry the reaction still further that reduced silver appears, and in removing this with nitric acid the double salt results. A confirmation of this is found in the fact that the treatment with nitric acid much reduces the deep terra cotta color of the original product. If this difficulty can be overcome we may yet obtain hemisalt isolated.

There is reason to suppose that numerous other compounds of silver hemioxide with oxyacids may exist. These compounds cannot be obtained by acting on the normal salts with sodium hypophosphite or with hypophosphorous acid, but it appears probable that they may be produced when the normal salts are formed in the presence of sodium hypophosphite. If to the last named salt we add a solution of a salt capable of precipitating silver nitrate, and then further add silver nitrate, we obtain precipitates which after standing some hours with frequent stirring appear to contain compounds of silver hemioxide. But these products do not resist the action of nitric acid; consequently there appears to be no means of purifying them and of deciding with certainty as to their nature.

When sodium citrate and hypophosphite are dissolved together and a little silver nitrate added to get rid of chlorides, then after standing and filtering more silver nitrate is added, a precipitate is obtained which after a time appears to contain silver hemicitrate in an impure form. When a little of this precipitate is put into much water containing a trace of ammonia (five or six drops to 100 c. c.), a fine rose-red solution results.

Most oxysalts of silver are darkened by light. In a paper published in this Journal for July, 1887, I mentioned that films of these salts exposed to light and then treated with dilute hydrochloric or hydrobromic acid appeared to be converted into hemichloride or hemibromide, and argued therefrom that oxyacid hemisalts of silver must exist, and be formed by action of light on normal salts. I believe that I have been able to prove the existence of a hemisulphate with a strong probability that many other hemisalts may be formed both by the action of light and also by purely chemical means. It is possible that at some future time we may succeed in obtaining some of these compounds in a state of purity.

SCIENTIFIC INTELLIGENCE.

I. Geology.

1. *Geology of the Taylorville Region of California;* by J. S. Diller, pp. 369–394 of the Bull. Geol. Soc. America, 1892.

Jura and Trias at Taylorville, California, by Alpheus Hyatt, pp. 395–412, ibid.

In these two papers is found the first recognition of the Lias in North America. The region of this discovery is in Plumas Co., California, near the summit of the Sierra Nevada, and is the same that afforded the fossils, in the survey under Professor J. D. Whitney, that were studied by Gabb and proved to represent the Upper Triassic and the Jurassic formations. The recent collections of Professor Hyatt have confirmed the results of Mr. Gabb, and, besides adding to the number of Upper Triassic species, have afforded over 40 Liassic, a large number of the Middle Jura or Oolite, and others that are referred to the Callovian and Corallian of the Upper Jura.

Mr. Diller, from his study of the stratigraphy of the region, makes the total thickness of its stratified rocks, exclusive of the gravels, to be over 24,500 feet. Of this series, about 17,500 are Paleozoic, 4700 Triassic, 450 Liassic, 530 Middle Jura, and 1000 Upper Jura—500 of the last in each of its subdivisions. The rocks are shown to be in overthrust flexures and upthrust faults, with the thrust in each to the eastward. Mr. Diller finds evidence that there was a profound upturning at the close of the Carboniferous; another feebler disturbance after the Triassic, and a great upturning again with flexures of the rocks after the Jurassic and probably immediately following this period. His paper contains sections illustrating the flexures and faults, with a full account of the stratigraphical results reached.

2. *Geological Survey of the State of New York. Palæontology: Volume VIII. An Introduction to the study of the genera of Palæozoic Brachiopoda. Part I.* By James Hall, State Geologist and Palæontologist, assisted by John M. Clarke. Albany, 1892, 4to, pp. i–xvi, 1–367, with 39 figures in the text and 44 lithographic plates.—Part I, now published, includes all the genera of palæozoic inarticulate brachiopods, together with the Orthoids, Strophomenoids, and Productoids of the articulate section. The Terebratuloids, Rhynchonelloids, Pentameroids, and spire-bearing forms are to appear in a subsequent volume. Practically this work fulfills the function of a final arbiter on questions of generic limitations. Great care has been taken to investigate type species and upon them to base the generic diagnoses. The manifest plan is to give of each genus, (*a*) accurate illustrations, (*b*) the bibliography and synonymy, (*c*) a diagnosis of internal and external characters, (*d*) the type species, (*e*) general observations on the structure and affinities,

and other facts of interest and importance. It would appear, at first sight, that a large number of new genera are proposed, and that most of the old familiar genera are present under unfamiliar guises, but a closer inspection shows that the number of actual new names is few. The others are rehabilitated terms, nearly forgotten since their origin, and now re-defined and applied to distinct groups of forms or types of structure. Thus the subject has been simplified by breaking up many of the old heterogeneous groups, such as *Discina* and *Orthis*, into clear cut minor genera or subgenera, which are now available for accurate systematic work. The authors have abstained from the exact use of family or other taxonomic designations except the two great divisions Inarticulata and Articulata.

Lingula is the first genus discussed, but it is not necessarily considered as the primitive type of inarticulate brachiopods. This view is supported by the geological history, anatomy, and development. *Lingulella* and *Lingulepis* are regarded as forerunners of *Lingula*, and connecting links to the Obolelloid type. Modifications of the nature of septa produced by the deposition of shelly matter about the muscular and parietal bands produced related genera, such as *Dignomia* and *Glottidia*. Special features developed about the cardinal areas resulted in forms for which the new generic terms *Barroisella* and *Tomasina* are proposed. Other structures arising from mechanical necessity, as the elevation of the anterior edges of the muscular attachments to compensate for hepatic and ovarian pressure resulted in the formation of the vaulted platform of *Lingulasma*. The authors consider this feature of much importance. It first appears in *Lingulops*, and reaches a higher development in *Lingulasma*. Whether this character in these genera is in direct genetic line to *Trimerella*, or whether it is a morphological equivalent, may be questions for further discussion.

Among Discinoid shells the new genus *Discinopsis* of Matthew is first defined, and the subgeneric divisions of *Orbiculoidea*, *Œhlertella*, *Lindstrœmella*, and *Rœmerella*, are proposed, based upon the features of the pedicle opening and form of the ventral valve. Of especial interest and importance are the observations on the development of the pedicle opening in *Orbiculoidea*, *Schizocrania*, *Trematis*, and *Discinisca*, showing their genetic relations in that *Discinisca* and *Orbiculoidea* pass through young stages comparable with adult conditions of *Schizocrania*.

Besides the current terms *Platystrophia*, *Bilobites*, *Schizophoria*, etc., founded upon groups which have been separated from *Orthis*, the authors have introduced seven new divisions making altogether fourteen including *Orthis* as restricted. The new names proposed are: *Plectorthis*, *Dinorthis*, *Plæsiomys*, *Hebertella*, *Heterorthis*, *Dalmanella*, and *Orthotichia*. Three new names are also applied to forms related to *Clitambonites* (= *Orthisina* d'Orb.); viz. *Billingsella*, *Protorthis*, and *Polytæchia*.

Many important changes have been introduced among the Strophomenoids and Productoids. *Strophomena* is restored to its original type *S. rugosa* Raf. = *Leptæna planumbona* Hall. This leaves most of the species known as *Strophomena*, and typified by *S. alternata*, without a name. For this group the genus *Rafinesquina* is proposed. *Leptæna* rests on its original species *L. rhomboidalis* Wilckens, sp. (= *L. rugosa* Dalman), and species for many years passing as *Leptæna sericea*, *L. transversalis*, etc., now fall under *Plectambonites* Pander, *Streptorhynchus* is restricted to a species of the type of *S. pelargonatum*, a Permian fossil, and nearly all the species commonly known under this designation from the Silurian and Devonian now come under the genus *Orthothetes* of Fischer de Waldheim. In addition to *Rafinesquina*, the following names are proposed for new generic and subgeneric types among the Strophomenoids and Productoids: *Orthidium*, *Kayserella*, *Pholidostrophia*, *Leptostrophia*, *Amphistrophia*, *Leptella*, *Christiania*, *Anoplia*, *Chonostrophia*, and *Chonopectus*.

It will probably be found that *Tropidoleptus* and *Vitulina* belong with the genera included in this volume. *Oldhamina*, *Lyttonia*, and *Richtofenia*, also pertain to this portion. It is hoped that a recognition of ordinal, subordinal, and patronymic subdivisions will be accorded in the final work as an expression of the views of the authors. Several anomalous inferences upon related genera which have a structurally intermediate genus appearing at a later geological period could perhaps be better explained as morphological equivalents. In other cases geratology is evidently an important factor.

Any just criticism of this work would deal chiefly with a few details of observations, minor differences of opinion, and trivial points of generic relationships, and would in no way impair its general usefulness. It must therefore stand as of the highest authority on the genera of Palæozoic Brachiopoda. C. E. B.

3. *Report of the Arkansas Geological Survey for 1890*, John C. Branner, State Geologist. Vol. III, *Whetstones and Novaculites of Arkansas*, by L. S. Griswold. 444 pp. 8vo, with colored geological maps and other illustrations.—Mr. Griswold's report has great value, alike historical, practical and scientific. The origin of the novaculite stratum, which in its pure form is 99½ per cent silica, is referred to simple sedimentation, like that of an ordinary sandstone; it is a very fine siliceous sand-deposit, somewhat calcareous, from which the minute calcareous grains have been leached out, so as to render the rock porous. Only small portions of the stratum have the fineness of texture fitted for the best whetstones. The stratum is of the age of the lower part of the Trenton, as proved by the author through the discovery of Graptolites, and has a thickness of about 1200 feet. It is underlaid by 1300 feet of shales, limestones and sandstones of older Paleozoic, and overlaid directly by 1200 to 1500 feet of Subcarboniferous beds, the Upper Silurian and Devonian

being absent. These rocks are upturned and in flexures, making ridges of what is called the Ouachita mountain system, extending from Little Rock, Central Arkansas, westward into the Indian Territory. The axis of uplift, about east and west in direction, "strikes toward the disturbed Paleozoic region between Mississippi and Tennessee, which region has been regarded as a southwestern termination of the Appalachian system."

4. *On the occurrence of Artesian and other underground waters in Texas, Eastern New Mexico and Indian Territory, west of the 97th Meridian;* by ROBERT T. HILL. 166 pp. 8vo, with numerons maps, plates, and sections. From the Final Reports of the Artesian and Underflow Investigations of the Department of Agriculture.—Professor Hill commences his very thorough Report with a general review of the topographical features of Texas. He mentions in detail the results of Artesian borings over the State, and discusses the observed facts in their relation to the several rock strata that underlie the surface, and the topography of the different regions. The special conditions on which in each region success or failure depend are pointed out, and in the explanations many geological details with regard to the stratification are given and made clear by numerous illustrating sections and maps.

5. *Geological Society of America.*—A meeting of the Geological Society, of which Professor G. K. Gilbert, is President, was held at Rochester, New York, on the 15th and 16th of August, immediately preceding that of the American Association. The following papers were read: L. C. Johnson, on Phosphate fields in Florida; C. H. Hitchcock, On the Connecticut Valley glacier; E. W. Claypole, Dentition of Titanichthys and its allies; G. C. Broadhead, On the Ozarks and the geological history of the Missouri Paleozoic; G. F. Becker, On the finite, homogeneous strain, flow and rupture of rocks; W. H. Hobbs, Phases in the metamorphism of schists in Southern Berkshire; C. L. Little, On a metamorphic conglomerate in the Green Mts.; J. Hall, On the Oneonta sandstone; W. Upham, On Drumlins; G. F. Wright, On Extra-morainic drift of the Susquehanna Valley; D. White, A new Tæniopterid and its allies; A. S. Tiffany, Overturn of L. Silurian strata in Rennselaer Co., N. Y.; President Gilbert, On Coon Butte of Arizona and the theories of its origin.

The Society will hold its next meeting at Ottawa, Canada, commencing on the 28th of December.

6. *Albirupean Studies;* by P. R. UHLER. Trans. Md. Acad. Sci., 1892, pp. 185–201.—We have here another strong effort of this author to vindicate his Albirupean formation, as outlined in 1888. He now expands it to include the entire clay series of New Jersey and the Laminated Sands of that state, also all of the Potomac formation of McGee coastward of the Iron Ore Clays of Maryland, and prolongs it southward into Virginia to take in the freestone quarries of Aquia Creek and Fredericksburg. This leaves very little of the great Atlantic Clay Belt for

any one to contend about, because it is now known that the Amboy Clay flora occurs near the base of the Tuscaloosa formation in Alabama and Mississippi. He has therefore proved too much and is anticipated by Dr. Eugene Smith, at least as to his proposed name. And really this is here the main thing, since the facts have been long known and accurately mapped, at least in New Jersey. The great question is that of correlating the Potomac formation with the New Jersey beds, or of showing what relation subsists between them. On this question the present paper throws no clear light. The one service which Prof. Uhler's investigations are doing is that of drawing attention to the fact that the great Lower Cretaceous non-shell-bearing belt of the Atlantic border region, though doubtless a geological unit (which he denies), occupied a vast period in its deposition, was attended by great vicissitudes and oscillations of level, and must be studied as a series of successive deposits rising stratigraphically from its landward toward its coastward margin and changing greatly from one level to another. L. F. W.

7. *The Fossil Flora of the Bozeman Coal Field;* by F. H. KNOWLTON. Proc. Biol. Soc. Washington, vol. vii, July 1892, pp. 153–154.—In this short paper Prof. Knowlton sums up the results of a prolonged investigation soon to be published in full by the Geological Survey. Altogether 43 species of fossil plants have been found in the Bozeman coal field only three of which are new, most of the others occurring in other parts of the west. The small number of Fort Union species seems to show that these deposits do not form a part of the series of beds that extend along the Missouri and Yellowstone rivers in Dakota and Montana. On the other hand the forms found are largely those of the true Laramie and overlying Denver formations of Colorado and Wyoming, between which they are pretty equally divided. This seems to fix the horizon of this coal region with considerable accuracy, and shows that the great Laramie sea occupied the same position relatively to the Rocky Mountain uplift in Montana as it does farther south. The most interesting form is the *Thinnfeldia polymorpha*, which seems to be a sort of connecting link between the ferns and the conifers of the Ginkgo type, and is also strongly suggestive of the Glossopterid forms of Australia and India. L. F. W.

8. *Paléontologie Végétale* (*Ouvrages publiés en* 1890), par R. ZEILLER. Extrait de l'Annuaire Géologique Universel, Tome VII, 1890, pp. 1115–1157, Paris, 1892. This is another of the series of admirable reviews of paleobotanical literature by M. Zeiller, of which four others have previously appeared. It is very thorough and searching, no less than 138 different works and papers being treated. The plan is to deal first with the general works and discussions and then to take up the special works in the ascending geological order of the formations. These are subdivided into Paleozoic, Antecretaceous Secondary, and Cretaceous and Postcretaceous. A special department is devoted to

fossil woods. The method is expository rather than critical and the space is well adjusted to the importance of the subjects reviewed. The literature is referred to by numbers and the titles are collected together in an alphabetical list, but unfortunately in a separate part of the volume (pp. 98–103)—a serious defect in the book-making, but for which our author is not responsible. The most important works that appeared during the year 1890 were Professor Fontaine's Flora of the Potomac Formation, Renault and Zeiller's Coal Flora of Commentry, Saporta's Jurassic Flora (completed in this year), the Paleophytology of Zittel's Handbuch, brought to a conclusion by Schenk, and Zeiller's Fossil Flora of the Carboniferous and Permian basin of Autun and Epinac. Among the leading discoveries of the year may be noted: that by Renault of the large petioles called Myeloxylon in direct relation with the ferns Alethopteris and Neuropteris; that by Williamson of secondary wood in certain ferns; that by Renault of a true Equisetum in the Carboniferous; that by Marion in the Permian of Lodève of peculiar strobiles (Gomphostrobus) which seem to form a connecting link between Walchia and Ginkgo; that by Saporta of dicotyledonous plants in the Lower Cretaceous of Portugal; and that by Dawson and Penhallow of a Rhizocarp (*Azollæphyllum primœvum*) allied to Azolla, in the Tertiary of British Columbia. L. F. W.

9. *Sylloge Fungorum Fossilium hucusque cognitorum.* Auctore A. Meschinelhi. Patavii, 1892.—This is an octavo pamphlet of 73 pages and will form part of the tenth volume o Saccardo's great *Sylloge Fungorum* so well known to botanists. It was well, and in line with modern methods, that Saccardo should include the fossil forms in his description of all the fungi known to botany, and this part could not have been intrusted to any one more competent than Professor Meschinelli. According to this enumeration there are now known to science 329 species of fossil fungi, which are assigned to 41 genera. Most of these latter are named from their resemblance to living genera by adding to the generic name the termination *-ites*. The largest genus is Sphærites with 100 species, which is followed by Xylomites with 56, Rhytismites with 23, Phacidites with 18, Depazites and Hysterites with 16 each, Phyllerites with 15, and Sclerotites with 13. Most of these occur as spots on dicotyledonous leaves, chiefly in the Tertiary. The genera Archagaricon, Peronosporites, Protomycites, Excipulites, and some of the species of other genera, are from the Carboniferous, and there are a few Mesozoic forms. The *Polyporites Bowmani* of Lindley and Hutton from the coal measures of Denbigshire, long regarded as the scale of a fish, is included, as is the *Gyromyces Ammonis* of Göppert, which most other authors treat as a shell, and which has been otherwise named *Spirorbis carbonarii*; but in such doubtful cases attention is called to the conflicting views. The plan of the work embraces pretty full references to the literature of each species, a very brief character, and a statement of the habitat, which

features render the work exceedingly useful independently of any questions as to the real nature of doubtful forms. L. F. W.

10. *I Tronchi di Bennettitee dei Musei Italiani. Notizie storiche, geologiche, botaniche;* dei Professori Senatore G. CAPELLINI e Conte E. SOLMS-LAUBACH. Con cinque tavole. Bologna, 1892. Estratta dalla Serie V, Tomo II delle Mem. Real Accad. Sci. Ist. di Bologna.—Capellini writes the historical and geological, and Solms-Laubach the botanical part of this memoir, giving a very full account of the discovery and the real nature of all the cycadean remains that have been long accumulating in the various Italian museums, one specimen dating back as far as 1745. Besides the eight species of Cycadeoidea which are described and figured one other form is treated as belonging to a different genus and named *Cycadea Imolensis.* Count Solms reserves the name Bennettites for the sole *B. Gibsonianus*, the nature of whose fructification is known and has been fully treated by him in a previous memoir (see this Journal, vol. xli, p. 331). Mention is made of three American forms. The specimen found at Golden, Colorado, to which Lesquereux gave the name *Zamiostrobus mirabilis* was sent to Solms-Laubach by the U. S. National Museum, with permission to dissect and describe it. It has been returned together with two slides showing its internal structure, but the only description is contained in letters from him. In these and in the present work he has renamed it *Cycadeoidea Zamiostrobus*, which name his label with the specimen also bears, but no figures are given. The *Tysonia Marylandica* of Fontaine from the iron ore clays (Potomac formation) of Maryland is also regarded as a Bennettites or a Cycadeoidea, and Capellini says that it closely resembles *C. Maraniana.* The *C. munita* of Cragin from the Cheyenne Sandstone is supposed to be a related form. L. F. W.

11. *Ueber den gegenwärtigen Standpunkt unserer Kenntniss von dem Vorkommen fossiler Glacialpflanzen.* Von A. G. NATHORST. Bihang till svenska Vet.-Akad. Handlingar. Band 17. Afd. III, No. 5. Stockholm, 1892.—It is matter for congratulation that this valuable paper should have been published in German instead of Swedish. It contains a résumé of the prolonged and extensive researches of the author into the occurrence of fossil plants in glacial deposits. These began nearly 25 years ago and his contributions to the subject embrace more than a score of titles. The present summary, however, goes further and includes the results of the labors of others, and, though brief, presents a bird's-eye view of the whole field. It is accompanied by a map of northern Europe with the areas and particular localities where these plants are found clearly marked. The principal countries in which these occur are: Sweden (chiefly in Scania at the extreme south, but also in Ostgothland, Gotland, and Jemtland), Norway (at Leine in Gudbrandsdalen), Denmark (Seeland, Möen, Bornholm, Jutland), Russia (Esthland, Livland), North Germany (East and West Prussia, Pomerania, Mecklen-

burg, Schleswig-Holstein), Great Britain (Devonshire, Norfolk, Suffolk, Yorkshire and near Edinburgh), Switzerland (Cantons of Zurich, Thurgau Luzern, Neuchâtel), Würtemberg (Upper Swabia), Bavaria (Kolbermoor), Hungary (Felek in the South Carpathian mountains), France (near Nancy). In nearly all cases the forms thus discovered have been identified with those now inhabiting the colder parts of the northern hemisphere. Their great southern range is conclusive as to the change that has taken place in the climate of Europe. L. F. W.

II. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*— The 41st meeting of this association was opened at Rochester, N. Y., on the 17th of August, under the Presidency of Professor Joseph LeConte. The addresses of the Vice-Presidents of the sections were as follows: Professor J. R. Eastman, of the Astronomical Section, On the neglected field of Fundamental Astronomy; Professor B. F. Thomas, of the Physical Section, On Technical education in High Schools and Universities; A. Springer, of the Chemical Section; On the Micro-organisms of the soil; H. S. Williams, of the Geological Section, On the Scope of Paleontology and its value to Geologists; Professor S. H. Gage, of the Biological Section, On the Comparative Physiology of respiration; W. H. Holmes, of the Section of Anthropology, On the evolution of the Esthetic; Professor J. B. Johnson, of the Section of Mechanical Science and Engineering, On the Applied Scientist; Lester F. Ward, of the Economical Science Section, On the Psychological basis of social economics.

The Address of the retiring President, Prof. A. B. Prescott, considered "the work that is wanted in the science of Chemistry."

Excursions were taken on Saturday in four directions, to Portage, Stony Brook Glen, Niagara Falls and Canandaigua Lake. The salt mines also, 20 to 30 miles south of Rochester, were visited.

The President and Vice-Presidents chosen for the following year were as follows: President, Wm. Harkness. Vice-Presidents, C. L. Doolittle, in the Mathematical and Astronomical section; E. L. Nichols, in the Physical; E. Hart, in the Chemical; S. W. Robinson, in that of Mechanical Science and Engineering; C. D. Walcott, in the Geological; H. F. Osborn, in the Zoological; C. E. Bessey, in the Botanical; J. O. Dorsey, in the Anthropological; W. H. Branner, in the Section of Economic Science and Statistics. Madison, Wisconsin, was selected for the next place of meeting.

List of papers accepted for reading.

Section A. Mathematics and Astronomy.

J. A. Brashear: European observations.

S. C. Chandler: On the conflict of observation with theory as to the earth's rotation.

D. P. TODD: Meteorological observations made in April, 1890, 1891, 1892, in the totality-path of the eclipse of 1893, April 16.

L. A. BAUER: The secular motion of a free magnetic needle.

M. MERRIMAN: On the discriminators of the discriminant of an algebraic equation.

G. E. HALE: The spectroheliograph of the Kenwood Astro-Physical Observatory, Chicago, and results obtained in the study of the sun. Forms of solar faculæ.

C. L. DOOLITTLE: Latitude of the Sayre Observatory. List of 30 new proper motion stars.

ALEXANDER MACFARLANE: On the imaginary of algebra.

R. S. WOODWARD: The iced-bar base apparatus of the U. S. Coast and Geodetic Survey. On the general problem of least squares.

A. W. PHILLIPS: Models and machines for showing curves of the third degree.

T. H. SAFFORD: Least square fallacies. Differential formulæ for orbit corrections. Proper motion of 89 stars within 10° of the north pole, with remarks on the present state of the problem of the solar motion.

E. HASTINGS MOORE: Concerning a congruence-group of order 360 contained in the group of linear fractional substitutions.

W. HOOVER: On the intersection of an equilateral hyperbola and the sides of a plane triangle—a question in trilinears.

W. A. ROGERS: On the construction of a prime vertical transit instrument for the determination of the latitude of Harvard College Observatory.

A. S. HATHAWAY: Lineo-linear vector functions.

E. B. FROST: Thermal absorption in the solar atmosphere.

J. E. KERSHNER: Electric lights for astronomical instruments.

J. D. WARNER: Practical rules for testing whether a number is divisible by 7, or any other small prime; and if not divisible, to ascertain the remainder. Increase in constant for addition in testing for integral values in the equation of quarter squares.

Section B. Physics.

E. S. FERRY: Persistence of vision.

G. W. HOLLEY: Experiments on the ocular spectrum of the eye and the image presented to the brain.

C. A. OLIVER: Description of a contrivance intended for the study of perception at definite distances.

E. MERRITT: Note on the photography of the manometric flame and the analysis of vowel sounds.

G. W. HOUGH: On the sensitiveness of photographic plates.

W. S. FRANKLIN: E. M. F. between normal and strained metals in voltaic cells.

M. MERRIMAN: Influence of the moon on the rainfall.

D. P. TODD: On the mechanical and physical means of aërial transit without a propeller.

E. B. ROSA: Further experiments on the specific inductive capacity of electrolytes.

C. B. THWING: A photographic method of mapping the magnetic field.

F. P. WHITMAN: Constancy of volume of iron in strong magnetic fields. Note on magnetic disturbances caused by electric railways.

E. L. NICHOLS: The distribution of energy in the spectrum of the glow-lamp. Absorption spectra of certain substances in the infra-red.

J. E. OLIVER: Note on the Lesage-Thomson theory of gravitation.

A. E. DOLBEAR: A mechanical model of electromagnetic relations.

W. L. STEVENS: An experimental comparison of formulæ for total radiation between 15° C. and 110° C.

H. RUBENS and B. W. SNOW: On the dispersion of radiations of great wavelengths in rock salt, silvite and fluorspar.

B. W. SNOW: On the distribution of energy in the arc. On the infra-red spectra of the alkalies.

G. HINRICHS: On the mechanics of the three states of aggregation.

Section C. Chemistry.

G. ARCHBOLD: The albuminoids of maize.

W. P. MASON: Post-mortem imbibition of arsenic. Effect of sedimentation upon self-purification of running streams. The value of a water analysis.

S. A. LATTIMORE: Presentation of samples from the salt mines of New York.

G. HINRICHS: On the mechanical determination of the stereographic constitution of organic compounds.

W. R. ORNDORFF: On the decomposition of acetone with concentrated sulfuric acid.

LAURA O. TALBOTT: Itacolumite from North Carolina.

H. CARRINGTON BOLTON: A select bibliography of chemistry.

A. TUCKERMAN: Notes on a bibliography of mineral waters.

E. HART: Copper sulfate as a material for standardizing solutions.

W. A. NOYES: An effective condenser for volatile liquids and for water analysis. Di-ethyl-carbinamin and its conduct toward nitrous acid.

A. B. PRESCOTT: The iodomercurates of organic bases.

M. GOMBERG: Tri-methyl-xanthin and its derivatives.

H. W. WILEY: Some points in connection with the composition of honey. A method of polarimetric observation at low temperatures.

C. P. TOWNSEND: Note on the effect of fertilizers upon the juice of the sugar-cane.

E. A. DE SCHWEINITZ: The enzyms or soluble ferments of the hog-cholera germ.

E. GOLDSMITH: Catalytic influence of ammonia on amorphous substances to induce crystallization.

Section D. Mechanical Science and Engineering.

J. B. JOHNSON: Extensometer for measuring distortion of specimens under test (instrument exhibited). Peculiar visible strain in steel when tested in tension, compression and cross-breaking.

FRED. T. GAUSE: Relative economy of the single cylinder air-compressor with cooling by a spray of water and the present economy of the compound compressors at Qua de la Gare, Paris.

A. M. ROSEBROUGH: A new window ventilating appliance.

WM. A. ROGERS: Investigation of a 21 1–1 feet precision screw. Exhibition and description of combined yard and meter standard bar.

R. S. WOODWARD: On the use of long steel-tapes in measuring base-line. Report of U. S. C. and G. Survey.

E. W. BEMIS: Results of municipal ownership of gas-works in the U. S. during 1891.

G. W. HOUGH: Description of a transmission dynamometer.

J. B. WEBB: Bending tests of timber.

J. E. DENTON: Method of measuring loss of power and drop of pressure between cylinders in multiple-cylinder engine.

D. S. JACOBUS: Measurements of total heats of combustion. Use of anemometers for measuring velocity of air in mines.

J. E. DENTON and D. S. JACOBUS: Steam economy of the engines of the screw ferry boat "Bremen."

DEVOLSON WOOD: Negative specific heats.

Section E. Geology and Geography.

A. HOLLICK: Paleobotany of the yellow gravel at Bridgeton, N. J.

G. F. KUNZ: The mining, metallurgical, geological and mineralogical exhibits to be shown at the World's Columbian Exposition

J. CRAWFORD: Cerro-Viejo and its cones of volcanic ejecta and extrusion in Nicaragua.

W. J. MCGEE: Pleistocene geography. Distributions of the LaFayette formation.

W. UPHAM: Submarine valleys on continental slopes.

E. D. COPE: Cenozoic beds of the staked plains of Texas.

A. L. AREY: Exhibitions of Guelph fossils found in Rochester, N. Y.

JOHN KOST: The American mastodon in Florida.

N. H. WINCHELL: Some problems of the Mesabi iron ore.

V. COLVIN: The mathematics of mountain sculpture.

R. T. HILL: The volcanic craters of the United States. Recent geological explorations in Mexico. The homotoxic relations of the North American Lower Cretaceous.

S. A. LATTIMORE: Presentation of samples from the salt mines of New York.

C. H. HITCHCOCK: Terminal moraines in New England.

E. W. CLAYPOLE: A passage in the history of the Cuyahoga River.

F. LEVERETT: Notes bearing upon the changes of the Pre-glacial drainage of western Illinois and eastern Iowa.

A. A. WRIGHT: Extra-morainic drift in New Jersey.

Section F. Biology.

J. C. ARTHUR: How the application of hot water to seed increases the yield.

L. H. BAILEY: On the supposed correlation of quality in fruits—a study in evolution.

W. J. BEAL: Spikes of wheat bearing abnormal spikelets. A study of the relative lengths of the sheaths and internodes of grasses for the purpose of determining to what extent this is a reliable specific character.

N. L. BRITTON: Notes on Ranunculus repens and its eastern North American allies. Notes on a monograph of the North American species of Lespedeza.

F. V. COVILLE: Geographic relationship of the flora of the high Sierra Nevada, California. Sketch of the Flora of Death Valley, California. Characteristics and adaptations of desert vegetation.

J. H. COMSTOCK: The descent of the Lepidoptera; an application of the theory of natural selection to toxonomy.

O. F. COOK: Do Termites cultivate fungi?

E. D. COPE: A new form of Marsupialia from the Laramie.

W. M. BEAUCHAMP: Variation in native ferns. Notes on some fresh water Mollusks.

W. A. KELLERMAN: Notes on yellow pitch-pine, *Pinus rigida* Mill, var. *lutea*. Germination at intervals of seed treated with Fungicides.

M. B. WAITE: The fertilization of pear flowers.

C. W. STILES: On the adult cestodes of cattle and sheep.

H. L. RUSSELL: Non-parasitic bacteria in vegetable tissue. Bacteriological investigations of marine waters and the sea floor.

H. E. WEED: The insect fauna of the Mississippi bottoms.

W. W. ROWLEE: The root system of Mikania scandens L. Adaptation of seeds to facilitate germination.

C. W. STILES: Report of Biological Section of the committee on the Naples table.

D. G. FAIRCHILD: Live-for-ever eradicated by a fungous disease.

G. VASEY: Otto Kunze's changes in nomenclature of North American grasses.

B. E. FERNOW and G. B. SUDWORTH: Revised nomenclature of the arborescent flora of the United States.

A. H. TUTTLE: The proposed Columbus biological stations in Jamaica. An interesting case of parasitism.

J. H. STOLLER: The conditions which determine the distribution of bacteria in the water of rivers.

C. W. HARGITT: Biological notes on fauna of Cold Spring Harbor. Notes on Daucus carota.

W. P. WILSON: Adaptation of plants to external environment.

S. A. BEACH: Notes on self-pollination of the grape.

G. B. SUDWORTH: Comparative influence of odor and color in attracting insects.

F. B. MAXWELL: Comparative study of the roots of Ranunculaceæ.

F. ROTH: Shrinkage of wood as observed under the microscope.

L. H. PAMMEL: Peziza sclerotium. Temperature and some of its relations to plant life.

B. D. HALSTED: Pleospora of Tropæolum majus. Secondary spores of Anthracnoses. A Bacterium of Phaseolus.

T. MEEHAN: The significance of cleistogamy.

E. W. DORAN: The animal parasites of dogs.

P. A. FISH: A preliminary note on the anatomy of the Urodela brain as exemplified by Desmognothus fusca.

J. B. SMITH: The "maxillary tentacles" of Pronuba.

L. M. UNDERWOOD: Preliminary comparison of the Hepatic Flora of boreal and sub-boreal regions.

E F. SMITH: On the value of wood ashes in the treatment of peach yellows. On the value of superphosphates and muriate of potash in the treatment of peach yellows.

G. MACLOSKI: Notes on maize.

G. S. HOPKINS: Contribution on the digestive tract of some N. A ganoids.

M. MILES: Heredity of acquired characters.

E. A. DE SCHWEINITZ: The production of immunity in guinea pigs from hog cholera by the use of blood serum from immunized animals.

S. P. GAGE: A preliminary account of the brain of Diemyctylus viridescens based upon sections made through the entire head.

C. V. RILEY: On Carphoxera ptelearia, the new herbarium pest. The fertilization of the fig and caprification.

R. O MOODY: Note on the appearance of two embryo chicks in a single blastoderm.

Section H. Anthropology.

D. G. BRINTON: Anvil-shaped stones from Pennsylvania. Proposed classification and international nomenclature of the anthropological sciences.

A. W. BUTLER: Some Indian camping sites near Brookville. Prehistoric objects from the White Water valley. On some remains from the oldest river gravels along the White Water river. Earthworks near Anderson, Ind.

L. L. CONANT: Primitive number system.

LAURA O. TALBOTT: A few psychological inquiries.

J. JASTROW: Involuntary movements.

MATILDA C. STEVENSON: Tusayan legends of the Snake and Flute people.

E. W. CLAYPOLE: A skull of a pig having a flint arrowhead imbedded in the bone.

W. J. MCGEE: Comparative chronology.

H. T. CRESSON: Brief remarks upon the alphabet of Landa.

F. W. PUTNAM: The Peabody Museum Honduras expedition. The Department of Ethnology of the World's Columbian Exposition. Exhibition of a large model of the Serpent Mound of Adams County, Ohio.

W. M. BEAUCHAMP: Early religion of the Iroquois. Early Indian forts in New York.

C. A. HIRSCHFELDER: Evidences of prehistoric trade in Ontario. Ancient earthworks in Ontario.

O. T. MASON: A definition of anthropology.

F. H. CUSHING: Pueblo myth and ceremonial dances.

C. P. HART: Demonstration of a recently discovered cerebral porta.

DOUGLAS: Ruins of Tiahuanaco.

S. S. SCOVILLE: Points concerning Fort Ancient.

T. B. REDDING: Pre-historic earthworks of Henry county, Indiana.

W. H. HOLMES: On the so-called paleolithic implements of the Upper Mississippi. The sacred pipestone quarry of Minnesota, and the ancient copper mines of Lake Superior. Aboriginal quarries of flakable stone, and their bearing upon the question of paleolithic man.

M. H. SAVILLE: Explorations on the main structure of Copan, Honduras. Vandalism among the antiquities of Yucatan and Central America.

H. C. MERCER: River pebbles chipped by modern Indians, as an aid to the study of the Trenton gravel implements.

W. K. MOOREHEAD: Cañon and mesa ruins in Utah. Singular copper implements and ornaments from the Hopewell group, Ross Co., Ohio.

2. *British Association.*—The sixty-second meeting of the British Association was held at Edinburgh during the week commencing August 3. Sir Archibald Geikie was the President of the meeting. In his address he speaks of the large contributions of Edinburgh geologists to geological science and dwells at length upon the prominent influence of the views of Hutton. Other Presidential addresses were by Professor Lapworth, of the Geological Section, on some general facts in the earth's development; Professor James Geikie, President of the Geographical Section, on the origin of coast lines; Professor Schuster, of the Physical Section, on the progress in Physical Science during the past year; Professor Wm. Rutherford, of the section on Biology, on the current theories regarding our sense of color. These and other Presidential addresses and reports of papers will be found in the numbers of Nature for the month of August and beyond.

3. *On the periodic variations in Glaciers.* The following is from a recent communication by Prof. Forel, published in Nature of August 18.—The preparatory study which we have made within the last few years has shown us that the periodicity of glacial variations is much longer than was formerly believed to be the case; the popular dictum that the increase in the size of glaciers recurs every seven years is certainly incorrect. We cannot yet give definite figures, but probably the cycle of glacial variation is as much as 35 to 50 years. The latter period alone has been studied attentively; if 1850 or 1855 be fixed upon as the epoch of maximum of glaciers, they have been steadily decreasing in past years, so that from 1870 to 1875 we were not aware of a single one on the increase. In 1875 the Glacier des Bossons du Mont Blanc gave the signal for a new period by commencing to lengthen out; it was followed in 1878 and 1879 by the glaciers of Trient and Zigiorenove; then successively by some thirty glaciers in different valleys of Le Valais; but the phase of increase is not yet general in Le Valais; a number of large glaciers, Arolla, Otemma, Corbassière, Le Gorner, Le Rhone, are still decreasing or stationary. It is only of the Mont Blanc group that the increase can be said to be general; in Le Valais it is in process of development, and we are still very far from the maximum stage of glaciers. If, as is probable, the maximum only arrives at the commencement of next century, the actual period of glaciers will have lasted more than fifty years.

4. *Florida, South Carolina and Canadian Phosphates;* by C. C. Hayes Millar. 224 pp. 8vo. 1892. New York (The Scientific Publishing Co.).—As the preface states, this book is addressed to those who are commercially interested in phosphates, and treats of their mode of occurrence, methods and cost of production, and commercial importance. It contains maps of the phosphate regions of Florida and South Carolina, and will be found a valuable work by those for whom it has been prepared.

APPENDIX.

ART. XLII.—*Restorations of Claosaurus and Ceratosaurus;* by O. C. MARSH. (With Plates VI and VII.)

A NUMBER of restorations of Dinosaurian reptiles have been recently made by the writer for the United States Geological Survey, and reduced figures of several of these have already appeared in this Journal; namely, *Brontosaurus* and *Stegosaurus* from the Jurassic, and *Triceratops* from the Cretaceous.* Two others of interest are given in the present article; *Claosaurus* from the Cretaceous, and *Ceratosaurus* from the Jurassic, as shown on Plates VI and VII. The former is a gigantic herbivorous reptile, a typical member of the *Ornithopoda*, and the latter a large carnivorous form of the *Theropoda*, as these orders have been defined by the writer.† Each of these two reptiles is a characteristic example of the great order in which it belongs, but both are highly specialized, and present many features not seen in earlier and more primitive types. Their representatives in the old world are *Iguanodon* and *Megalosaurus*, although each of the four genera may represent a distinct family.

It is especially fortunate that each of the restorations here presented is based upon the remains of a single individual in which both the skull and skeleton were found in position, and in remarkable preservation. Additional remains, apparently identical with each, have also been secured, and these have cleared up several points which otherwise might have been left in doubt. These various remains have already been described by the writer, and the most important parts figured.

* This Journal, vol. xli, p. 339, April, 1891; and vol. xlii, p. 179, August, 1891.
† Ibid., vol. xxi, p. 423, May, 1881; and vol. xxiii, p. 84, January, 1882.

Claosaurus, Marsh, 1890.*

The most important feature in the restoration of *Claosaurus annectens* given on Plate VI is the skull, which will be fully described elsewhere, but its main features may be noticed here. This skull is long and narrow, with the facial portion especially produced. The anterior part is only moderately expanded transversely, thus differing from that of *Hadrosaurus* (*Diclonius*), a nearly allied form.. Seen from the side, the skull of *Claosaurus* shows a blunt, rugose muzzle, formed above by the premaxillary and below by the predentary, both probably covered in life with a thick, corneous integument.

Behind the upper part of this muzzle is an enormous lateral cavity, which includes the narial orifice, but was evidently occupied in life mainly by a nasal gland, somewhat like that in the existing Monitor, and also seen in some Birds. This cavity is bounded externally by the nasal bone and the premaxillary. The orbit is very large, and subtriangular in outline. It is formed above by the prefrontal, frontal, and postfrontal, and below mainly by the jugal. There are no supra-orbital bones. A distinct lachrymal forms a portion of the anterior border. The infra-temporal fossa is large, and bounded below by the jugal. There is a thin quadrato-jugal between the jugal and quadrate. The occipital condyle is directed backward and downward.

The nasals are very long and slender, and in front are separated by the narrow superior processes of the premaxillaries. The frontals are short and broad, and somewhat concave above. The parietals are firmly coössified, and very small, forming a thin partition between the supra-temporal fossæ. The latter are bounded posteriorly by the massive squamosals, which contain a deep cavity for the head of the quadrate, and also overlap the exoccipitals.

The striking features of the lower jaw are the massive, rugose predentary, the large and powerful dentary bone with its robust coronoid process, and the very small angular and articular bones.

The teeth are confined entirely to the maxillary and dentary bones. They closely resemble those of *Hadrosaurus*, are arranged in the same manner, and appear to be equally numerous.† They were well adapted to a diet of soft succulent vegetation.

* This Journal, vol. xxxix. p. 423, May, 1890; vol. xliii, p. 453, May, 1892; and vol. xliv, p. 171, August, 1892.

† The description given by Cope of the skull of *Hadrosaurus* (*Diclonius*) *mirabilis*, Leidy, is erroneous in various important points. Among the more serious errors are the following: the predentary bone is mistaken for the dentary, the dentary is regarded as the surangular and as the splenial, while the squamosal is called the parietal. See Proc. Phil. Acad., 1883, p. 97, plates iv–vii.

The main characters of the vertebral column of *Claosaurus* are well shown in the restoration. There are thirty vertebræ between the skull and sacrum, nine in the sacrum, and about sixty in the tail. The whole vertebral column was found in position except the terminal caudals, which are here represented in outline. The cervical vertebræ are strongly opisthocœlian, and the first eleven have short ribs. The dorsals are also opisthocœlian. There are no true lumbar vertebræ, as the last of those in front of the sacrum support free ribs. The anterior caudals are opisthocœlian. The first and second have no chevrons. Behind these, the chevron bones are very long, indicating a powerful, compressed tail, well adapted for swimming.

In the median dorsal region, between the ribs and the neural spines, are numerous rod-like ossified tendons, which increase in number in the sacral region and along the base of the tail, and then gradually diminish in number and size, ending at about the thirty-fifth caudal. These ossified tendons are well shown in the restoration, and are of much interest. They are not unlike those in *Iguanodon* described by Dollo, but as a rule are more elongate, and appear to lack the definite arrangement in rhomboidal figures observed in that genus.*

The fore limbs are unusually small in comparison with the posterior, and the relative size of the two is well shown in the restoration. The scapular arch presents many points of interest. The scapula is large, and so much curved that its shaft is nearly at right angles to the articular faces of its lower extremity. On the anterior margin, above the articulation for the coracoid, is a strong protuberance, with a well-defined facet, adapted to the support of the clavicle, if such a bone were present. The coracoid is very small, and is perforated by a large foramen. The two peculiar bones now generally regarded as belonging to the sternum were not coössified.

The humerus is comparatively short. The radius and ulna are much elongated, the latter being longer than the humerus, and the radius about the same length. The ulna has a prominent olecranon process, and is a stouter bone than the radius. The carpal bones were quite short, and appear to have been only imperfectly ossified. The fore foot, or manus, was very long, and contained three functional digits only. The first digit was rudimentary, the second and third were nearly equal in length, the fourth was shorter and less developed, and the fifth entirely wanting, as shown in Plate VI.

In the functional digits (II, III, IV), the phalanges are elongate, thus materially lengthening the fore foot. The terminal phalanges of these digits are broad and flat, showing

* Archives de Biologie, tome vii, p. 249, Gand, 1886.

that they were covered with hoofs, and not with claws. The limb as a whole was thus adapted to locomotion or support, and not at all for prehension, although this might have been expected from its small size and position.

The elongation of the fore arm and manus is a peculiar feature, especially when taken in connection with the ungulate phalanges. It may, perhaps, be explained by supposing that the animal gradually assumed a more erect position until it became essentially a biped, while the fore limbs retained in a measure their primitive function, and did not become prehensile, which was the case in some allied forms.

The pelvis has already been described by the writer. Its most notable features are seen in the pubis and ischium, the former having a very large expanded prepubis with the postpubis rudimentary, while the shaft of the ischium is greatly elongated.

The femur is long, and the shaft nearly straight. The great trochanter is well developed, while the third trochanter is large and near the middle of the shaft. The external condyle of the distal end is projected well backward, indicating great freedom of motion at the knee.

The tibia is shorter than the femur, and has a prominent cnemial crest. The distal end is much flattened, and the astragalus is closely adapted to it. The fibula is very straight, with its lower end flattened and closely applied to the front of the tibia. The calcaneum is large, with its concave upper surface closely fitted to the end of the fibula. Of the second row of tarsals, only a single one appears to be ossified, and that is very small and thin, and placed between the calcaneum and the fourth metatarsal, nearly or quite out of sight.

The hind foot, or pes, had but three digits, the second, third, and fourth, all well developed and massive. The terminal phalanges were covered with broad hoofs. The first and fifth digits were entirely wanting.

All the limb bones in *Claosaurus* are solid, thus distinguishing it from *Hadrosaurus*. The separate ischium, not coössified with the pubis, the absence of a fourth digit in the hind foot, and other marked characters, also make the genus distinct from *Pteropelyx*, the skull of which is not known.

The reptile here restored was nearly thirty feet in length when alive, and about fifteen in height in the position represented in Plate VI. The remains were obtained by Mr. J. B. Hatcher and Mr. A. L. Sullins, in the Ceratops beds of the Laramie, in Wyoming. Among the associated fossils are the gigantic *Triceratops* and *Torosaurus*, which were also herbivorous Dinosaurs, and with them were found the diminutive Cretaceous mammals recently described by the writer.

Ceratosaurus, Marsh, 1884.*

In the same horizon of the Jurassic in which *Brontosaurus* and *Stegosaurus* were found, the skeleton restored in Plate VII was likewise discovered. It is a typical carnivorous Dinosaur of moderate size, and doubtless was one of the various enemies of the large herbivorous forms. The restoration represents the reptile one-thirtieth natural size, and in a position it must have frequently assumed.

The skull of *Ceratosaurus nasicornis* is very large in proportion to the rest of the skeleton. The posterior region is elevated, and moderately expanded transversely. The facial portion is elongate, and tapers gradually to the muzzle. Seen from above, the skull resembles in general outline that of a crocodile. The nasal openings are separate and lateral, and are placed near the end of the snout, as shown in Plate VII.

Seen from the side, this skull appears Lacertilian in type, the general structure being light and open. From this point of view, one special feature of the skull is the large, elevated, trenchant horn-core situated on the nasals. Another feature is the large openings on the side of the skull, four in number. The first of these is the anterior nasal orifice; the second, the very large triangular antorbital foramen; the third, the large oval orbit; and the fourth, the still larger lower temporal opening.

The parietal bones are of moderate size, and there is no parietal foramen. The median suture between the parietals is obliterated. The frontal bones are rather short, and are closely united on the median line. The nasal bones are more elongate than the frontals, and are firmly coössified. These bones support the large, compressed, elevated horn-core, on the median line. The lateral surface of this elevation is very rugose, and furrowed with vascular grooves. It evidently supported a high, trenchant horn, which must have formed a most powerful weapon for offense and defense.

The premaxillaries are separate, and each contained three functional teeth. The maxillary bones are large and massive, as shown in Plate VII. They are provided each with fifteen functional teeth, which are large, powerful, and trenchant, indicating clearly the ferocious character of the animal when alive. These teeth have the same general form as those of *Megalosaurus*, and the dental succession appears to be quite the same. Above the antorbital foramen on either side is a high elevation composed of the prefrontal bones. These protuberances would be of service in protecting the orbit, which they partially overhang.

* This Journal, vol. xxvii, p. 329, April, 1884; and vol. xxviii, p. 161, August, 1884.

The lower jaws of *Ceratosaurus* are large and powerful, especially in the posterior part. In front, the rami are much compressed, and they were joined together by cartilage only. There were fifteen teeth in each ramus, similar in form to those of the upper jaws.

The cervical vertebræ of *Ceratosaurus* differ in type from those in any other known reptiles. With the exception of the atlas, all are strongly opisthocœlian, the cup on the posterior end of each centrum being unusually deep. In place of an equally developed ball on the anterior end, there is a perfectly flat surface. The size of the latter is such that it can only be inserted a short distance in the adjoining cup. This peculiar articulation leaves more than three-fourths of the cup unoccupied by the succeeding vertebra, forming, apparently, a weak joint.

The dorsal and lumbar vertebræ are bi-concave, with only moderate concavities. The sides and lower surface of the centra are deeply excavated, except at the ends. All the presacral vertebræ are very hollow, and this is also true of the anterior caudals.

There are five well coössified vertebræ in the sacrum of the present specimen of *Ceratosaurus nasicornis*. The transverse processes are very short, each supported by two vertebræ, and they do not meet at their distal ends. The caudal vertebræ are bi-concave. All the anterior caudals, except the first, supported very long chevrons, indicating a high, thin tail, well adapted to swimming. The tail was quite long, and the distal caudals were very short.

The scapular arch of *Ceratosaurus* is of moderate size, but the fore limbs are very small. The humerus is short, with a strong radial crest. The radius and ulna are also very short, and nearly equal in size. The carpal bones were only imperfectly ossified. There were four digits in the fore foot, and all were armed with sharp claws. The second and third digits were much larger than the first and fourth, and the fifth was entirely wanting.

The pelvic arch of *Ceratosaurus* is of special interest. In the type specimen here restored, the ilium, ischium, and pubis, on each side, are firmly coössified. The ilia, moreover, are attached to the sacrum, which was in place in the skeleton. The ilia have the same general form as in *Megalosaurus*. The ischia are comparatively slender. They project well backward, and for the last half of their length the two are in close apposition. Their distal ends are coössified and expanded, as shown in Plate VII.

The pubes have their distal ends coössified, and expand into an elongate, massive foot, which is one of the most characteristic parts of the skeleton. It is probable that this foot in connection with the distal ends of the ischia served to support the body in sitting down. That some Triassic Dinosaurs sat down on their ischia is proved conclusively by the impressions in the Connecticut River sandstone. In such cases, the leg was bent so as to bring the heel to the ground. The same action in the present reptile would bring the foot of the pubes to the ground, nearly or quite under the center of gravity of the animal. The legs and ischia would then naturally aid in keeping the body balanced. Possibly this position was assumed habitually by these ferocious biped reptiles, in lying in wait for their prey.

The femur is much curved, and the shaft very hollow. The tibia is shorter than the femur, nearly straight, and has a large cnemial crest. The astragalus is not coössified with the tibia, and has a strong ascending process. The fibula is well developed, and nearly straight, its distal end fitting into the calcaneum. The tarsals of the second row are very thin, and united to the metatarsals below them.

The most interesting feature in the extremities of this Dinosaur is in the metatarsal bones, which are completely ankylosed, as are the bones of the pelvis. There are only three metatarsal elements in each foot, the first and fifth having apparently disappeared entirely. The three metatarsals remaining, which are the second, third, and fourth, are proportionally shorter and more robust than in the other known members of the *Theropoda*, and being firmly united to each other, they furnish the basis for a very strong hind foot. The phalanges of the hind feet are of moderate length, and most of them are quite hollow. The terminal phalanges evidently supported strong and sharp claws.

The unique cervical vertebræ, the coössification of the pelvic bones, and the union of the metatarsals, as in modern Birds, distinguish *Ceratosaurus* widely from all other Dinosaurs, and make it the type of a well-marked family, the *Ceratosauridæ*. The nearest allied form is apparently *Ornithomimus*, from the Laramie, recently described by the writer.

The type specimen of *Ceratosaurus* was about twenty-two feet long when alive, and twelve feet high as here restored. It was found by Mr. M. P. Felch, in the Atlantosaurus beds of the upper Jurassic in Colorado. The associated fossils were mainly other Dinosaurs, especially *Sauropoda* and *Ornithopoda*, together with various small mammals.

New Haven, Conn., September 22, 1892.

ART. XLIII.—*Restoration of Mastodon Americanus*, Cuvier; by O. C. MARSH. (With Plate VIII.)

THE great abundance and good preservation of the remains of the American *Mastodon* have led to various restorations of the skeleton. The best known of these is that made by Prof. Richard Owen, in 1846, based upon a skeleton from Missouri now in the British Museum.* Another restoration was made a few years later by Dr. J. C. Warren, based mainly on a very perfect skeleton from Orange county, New York.† This skeleton is now preserved in the Warren Museum in Boston. A third restoration was made by Prof. James Hall, from a skeleton found at Cohoes, New York, and now in the State Museum of Natural History, in Albany.‡ These restorations are all of importance, and taken together have made clear to anatomists nearly all the essential features of the skeleton of this well-known species.

Additional discoveries have since brought to light more perfect specimens, one of which, now in the Yale Museum, is perhaps in the best preservation of any skeleton of the American *Mastodon* yet discovered, and this has been used by the writer in the restoration, one thirty-second natural size, given on Plate VI, which is reduced from a large drawing made for the United States Geological Survey.

The position chosen in this restoration is one which seems especially fitted to bring out the massive proportions of the animal, and, at the same time, to show nearly all the characteristic features of the entire skeleton. The animal as thus represented was, when alive, about twelve feet in height, and perhaps twenty-four feet in length including the tusks.

This animal was fully adult, as the last molars above and below are in place and somewhat worn. The epiphyses of the vertebræ, moreover, are nearly all coössified with the centra, and in some of them, the sutures are obliterated. The epiphyses are also firmly united to the limb bones.

The tusks were very large, and considerably divergent. There were no inferior tusks, and no traces of their alveoli remain. The penultimate and last molars are present above and below in fine preservation, the former considerably worn.

Other features of this skeleton, and especially the various new anatomical points it discloses, will be discussed by the writer in another communication.

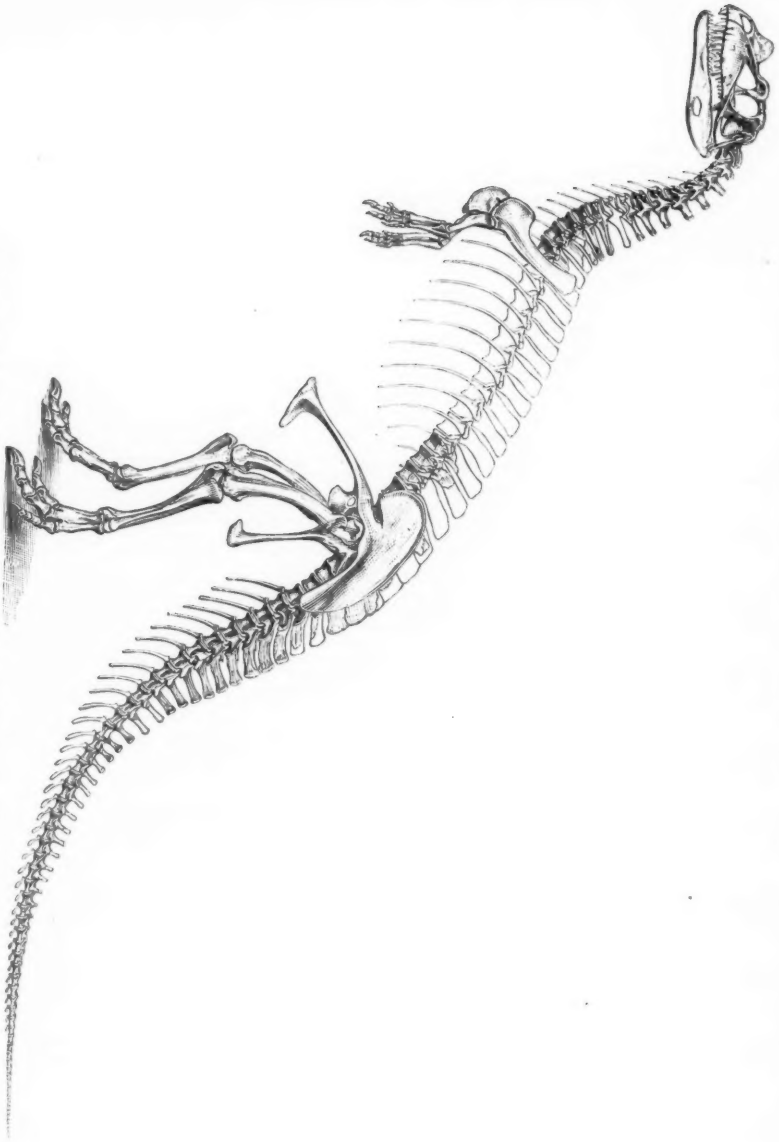
New Haven, Conn., September 23, 1892.

* British fossil Mammals and Birds, figure 102, p. 298, London, 1846.

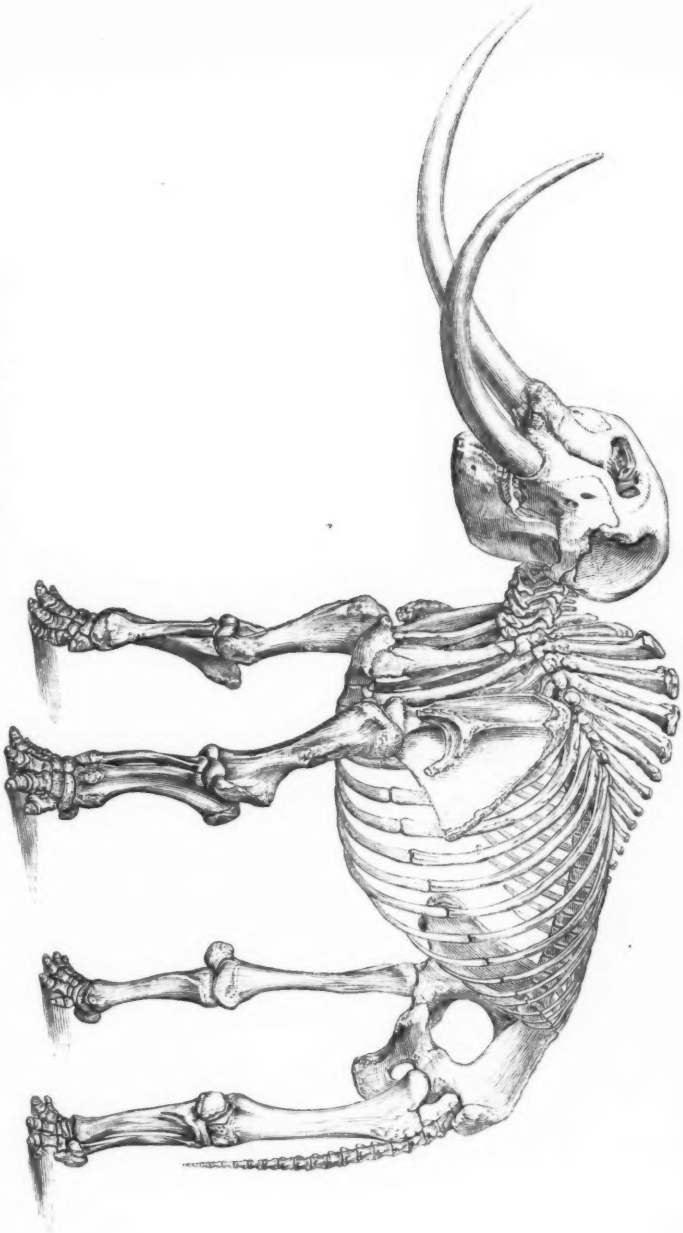
† Description of a skeleton of the *Mastodon giganteus* of North America, plate xxvii. Boston, 1852.

‡ Report of the New York State Cabinet of Natural History for the year 1867 plate vi. Albany, 1871.

Restoration of CLAOSAURUS ANNECTENS, Marsh. One-fortieth natural size.



Restoration of CERATOSAURUS NASICORNIS, Marsh. One-thirtieth natural size.



Restoration of MASTODON AMERICANUS, Cuvier. One thirty-second natural size.

EDWIN E. HOWELL, Proprietor.

RELIEF MAPS AND MODELS.

Especial attention given to Relief Maps. All work of this kind executed accurately and artistically. Also copies furnished of models made for the government; Grand Cañon of the Colorado, Yosemite Valley, Wasatch and Uinta Mountains, Mt. Taylor, Mt. Shasta, Leadville, Eureka, Yellowstone National Park, etc., etc. Also model of the whole **United States** with adjoining *Ocean bottoms, modeled on correct curvature.*

SYSTEMATIC COLLECTIONS.

With unusual facilities for securing educational materials it is proposed to lead all establishments in furnishing systematic collections for teaching **Mineralogy, Geology,** and **Zoology** in Schools and Colleges. Individual specimens also furnished.

METEORITES.

Write me if you have meteorites to sell, or wish to buy, or have them cut and polished.

ANATOMICAL MODELS, TAXIDERMY, Etc.

Can furnish DANA'S NEW SYSTEM OF MINERALOGY for $10.00. Postpaid, $10.30.

Send for Circular.

EDWIN E. HOWELL,
612 17th St., N. W., Washington, D. C.

BECKER BROTHERS,

No. 6 Murray Street, New York,

Manufacturers of Balances and Weights of Precision for Chemists, Assayers, Jewelers, Druggists, and in general for every use where accuracy is required.

DR. F. KRANTZ,

RHENISH MINERAL OFFICE,

BONN ON THE RHINE, GERMANY.

ESTABLISHED 1833.

Manufactory for working models of crystals in wood and glass with mathematical exactness. The models of crystals of table glass including the colored axes, or as regards hemiëdrical crystals, including the holædric form in wood, represent for larger auditories an indispensable object for declaring the simple and the hemiëdrical forms of crystals.

I. CRYSTAL MODELS IN WOOD.

a. **Collection of 30 models,** general size of 5 cm., $ 5.00.
(Principal forms), " " 10 cm., 10.00.
b. **Collection of 50 models,** " " 5 cm., 9.00.
c. **Collection of 80 models,** " " 5 cm., 19.00.

The collections b and c are arranged with regard to the instruction in schools and contain with the principal forms also the important combinations and twin crystals.

d. **Collection of 132 models,** according to a catalogue arranged by Prof. Fr. C. Hintze, containing all simple forms (holohedral, hemihedral and tetrahedral), and the most important combinations. General size of 5 cm., $31.00.

e. **Systematical-crystallographic collection of 412 models,** arranged by Professor P. Groth, containing all crystal-forms, combinations and derivative series represented in the Manual of Physical Crystallography of Prof. P. Groth (2. edit., Leipzig, 1885). General size of 5 cm., $150.00; general size of 10 cm., $412.00.

Of this collection can be furnished the complete series of the 88 colored models, representing the derivation of the hemihedral and tetrahedral forms. General size of 5 cm., $50.00; general size of 10 cm., $138.00.

f. **Mineralogical-crystallographic collection.**

1. **Collection of 743 models,** according to a catalogue arranged by Prof. P. Groth (1880), containing typical models of all crystallized minerals. General size of 5 cm., $300.00.

2. **Collection of 213 models,** acording to a catalogue arranged by Prof. P. Groth (1887), containing the most interesting combinations described since 1880. It is a *supplement to the collection of 743 models.* General size of 5 cm., $162.00.

g. **Collection of 10 models,** representing the forms of the oxalate of calcium in plants. General size of 5 cm., $3.00.

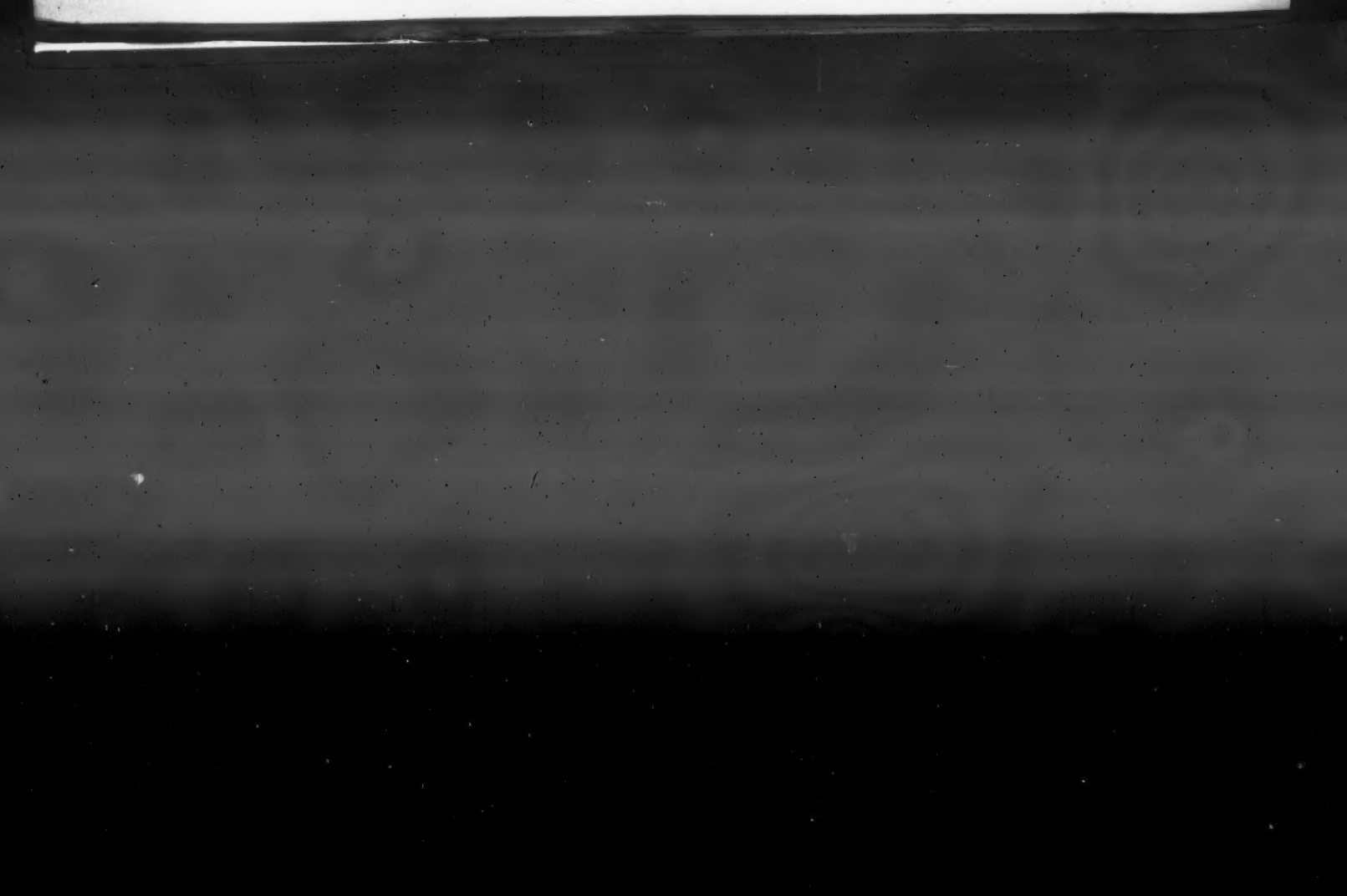
II. CRYSTAL MODELS IN TABLE-GLASS.

Collection of 50 models, containing the principal forms of the six crystallographic systems and derivative series of the hemidedral forms. General size of 15–25 cm., $44.90.

All models named in the above collections can be furnished also separately. New crystal-models can be worked after crystallographic drawings at any time.

CATALOGUES RECENTLY PUBLISHED.

Catalogue No. II.—*Paleontology, General Geology.* Illustrated.
Catalogue No. IV.—*Kinds of Rocks. Twin sections of rock for microscopical studies.*



A. E. FOOTE, M.D.,

4116 Elm Avenue, **Philadelphia, Pa., U. S. A.**

Systematic Collections for schools, colleges, teachers and students. Series to illustrate the physical characters of minerals, their uses in the arts, manufactures, etc., etc.

Illustrated Catalogue of Minerals, Mineralogical Books, 128 pp., Free.

RECENT ADDITIONS.

SCANDINAVIAN MINERALS.

We have just heard from Prof. Foote, who has spent most of August and part of September at the most celebrated localities of Sweden and Norway. Full lists will soon be published of his very remarkable collections which place **Eudidymite, Cobaltite, Svabite. Pajsbergite, Kongsberg silvers, Bamle Enstatites, Ganomalite, Brandtite, Native Lead, Sarkinite,** and many of the rare arsenates within the reach of the student. We append an incomplete list of the best minerals obtained:

Hedenbergite, Pyrosmalite, fine Enstatite crystals, Sunstone, Orangite, Thorite (one ½ pound crystal), **Kjerulfine crystals** (very rare), **Talc pseudomorphs, Rutile, Dahllite, Melanite, Iolite, Euxenite** of fine quality, groups of **Babingtonite, Leucophanite, Monazite** and **Xenotime crystals, Bragite, Columbite, Gadolinite, Keilhauite crystals, Alvite, Vesuvianite var., Egeran, Molybdenite, Scapolite, Caryopilite, Flinkite, Pyroaurite, Ochrolite, Trimerite, Melanocerite, Barkevikite, Catapleite, Eucolite, Hiortdahlite, Homilite, Helvite, Johnstruppite, Lovenite, Meliphanite, Mosandrite, Tritonite, Rosenbuschite, Pyrochlore.**

Perhaps the finest specimen secured is a two hundred pound mass of the Greenland Iron which was collected by Baron Nordenschiold and figured by him in the account of his trip published in 1870. This will form part of Prof. Foote's exhibit at Chicago.

ENGLISH AND GERMAN MINERALS.

Full lists of the minerals collected and purchased at the German and English localities will be sent on application.

MILLERITE.

A lot recently received from Keokuk, Iowa, contains the most beautiful specimens of Millerite we have ever seen. The delicate capillary crystals occur with bright and clear Calcite, filling the cavities and penetrating the surrounding crystals. Drawer and shelf specimens, 25 cts. to $3.00.

CRYSTALLIZED MANGANOPECTOLITE.

Numerous shipments from Magnet Cove yielded a few unique groups. The crystals are large and in several instances quite perfect. A fresh stock of **Monticellite, Pseudoleucite, Eudialyte,** geniculated **Rutile** and bright **Brookites.**

☞ *Any of the above will be sent on approval.*

We have also received very large additions to our stock of *Books*, by purchases of Libraries, etc., made in *Europe* by Prof. Foote and also in *America*. Our stock now is most complete on every branch of Science and Medicine. Catalogues free. Please mention what subject you are interested in.

CONTENTS.

Page

ART. XXXIV.—On a Color System; by O. N. ROOD 263

XXXV.—An Ottrelite-bearing phase of a Metamorphic Conglomerate in the Green Mountains; by C. L. WHITTLE. 270

XXXVI.—Age-Coating in Incandescent Lamps; by E. L. NICHOLS 277

XXXVII.—Mica-peridotite from Kentucky; by J. S. DILLER 286

XXXVIII.—Glaciation in the Finger-Lake region of New York; by D. F. LINCOLN 290

XXXIX.—Certain Points in the Interaction of Potassium Permanganate and Sulphuric Acid; by F. A. GOOCH and E. W. DANNER 301

XL.—Crystallography of the Cæsium-Mercuric Halides; by S. L. PENFIELD 311

XLI.—Silver Hemisulphate; by M. C. LEA 322

APPENDIX.—XLII.—Restorations of Claosaurus and Ceratosaurus; by O. C. MARSH. (With Plates VI and VII) . 343

XLIII.—Restoration of Mastodon Americanus, *Cuvier;* by O. C. MARSH. (With Plate VIII) 350

SCIENTIFIC INTELLIGENCE.

Geology—Geology of the Taylorville Region of California, J. S. DILLER: Jura and Trias at Taylorville, A. HYATT: Geological Survey of the State of New York: Palæontology, Vol. VIII, J. HALL, 330.—Report of the Arkansas Geological Survey for 1890, Vol. III, Whetstones and Novaculites of Arkansas, L. S. GRISWOLD, 332.—Occurrence of Artesian and other underground waters in Texas, etc., R. T. HILL: Geological Society of America: Albirupean Studies, P. R. UHLER, 333.—Fossil Flora of the Bozeman Coal Field, F. H. KNOWLTON: Paléontologie Végétale (Ouvrages publiés en 1890), R. ZEILLER, 334.—Sylloge Fungorum Fossilium hucusque cognitorum, A. MESCHINELHI, 335.—Tronchi di Bennettitee dei Musei Italiani, G. CAPELLINI and E. SOLMS-LAUBACH: Ueber den gegenwärtigen Standpunkt unserer Kenntniss von dem Vorkommen fossiler Glacialpflanzen, A. G. NATHORST, 336.

Miscellaneous Scientific Intelligence—American Association for the Advancement of Science, 337.—British Association: Periodic variations in Glaciers: Florida, South Carolina and Canadian Phosphates, C. C. H. MILLAR, 342.